
Appendix

TABLES

Table I Trigonometric Functions

Degrees	Radians	Sin	Tan	Cot	Cos		
0	.000	.000	.000		1.000	1.571	90
1	.017	.017	.017	57.29	1.000	1.553	89
2	.035	.035	.035	28.64	.999	1.536	88
3	.052	.052	.052	19.081	.999	1.518	87
4	.070	.070	.070	14.301	.998	1.501	86
5	.087	.087	.087	11.430	.996	1.484	85
6	.105	.105	.105	9.514	.995	1.466	84
7	.122	.122	.123	8.144	.993	1.449	83
8	.140	.139	.141	7.115	.990	1.431	82
9	.157	.156	.158	6.314	.988	1.414	81
10	.175	.174	.176	5.671	.985	1.396	80
11	.192	.191	.194	5.145	.982	1.379	79
12	.209	.208	.213	4.705	.978	1.361	78
13	.227	.225	.231	4.331	.974	1.344	77
14	.244	.242	.249	4.011	.970	1.326	76
15	.262	.259	.268	3.732	.966	1.309	75
16	.279	.276	.287	3.487	.961	1.292	74
17	.297	.292	.306	3.271	.956	1.274	73
18	.314	.309	.325	3.078	.951	1.257	72
19	.332	.326	.344	2.904	.946	1.239	71
20	.349	.342	.364	2.747	.940	1.222	70
21	.367	.358	.384	2.605	.934	1.204	69
22	.384	.375	.404	2.475	.927	1.187	68
23	.401	.391	.424	2.356	.921	1.169	67
24	.419	.407	.445	2.246	.914	1.152	66
		Cos	Cot	Tan	Sin	Radians	Degrees

(Table I is continued on the next page.)

Table I Trigonometric Functions (continued)

Degrees	Radians	Sin	Tan	Cot	Cos		
25	.436	.423	.466	2.144	.906	1.134	65
26	.454	.438	.488	2.050	.899	1.117	64
27	.471	.454	.510	1.963	.891	1.100	63
28	.489	.469	.532	1.881	.883	1.082	62
29	.506	.485	.554	1.804	.875	1.065	61
30	.524	.500	.577	1.732	.866	1.047	60
31	.541	.515	.601	1.664	.857	1.030	59
32	.559	.530	.625	1.600	.848	1.012	58
33	.576	.545	.649	1.540	.839	.995	57
34	.593	.559	.675	1.483	.829	.977	56
35	.611	.574	.700	1.428	.819	.960	55
36	.628	.588	.727	1.376	.809	.942	54
37	.646	.602	.754	1.327	.799	.925	53
38	.663	.616	.781	1.280	.788	.908	52
39	.681	.629	.810	1.235	.777	.890	51
40	.698	.643	.839	1.192	.766	.873	50
41	.716	.656	.869	1.150	.755	.855	49
42	.733	.669	.900	1.111	.743	.838	48
43	.750	.682	.933	1.072	.731	.820	47
44	.768	.695	.966	1.036	.719	.803	46
45	.785	.707	1.000	1.000	.707	.785	45
		Cos	Cot	Tan	Sin	Radians	Degrees

Table II Greek Alphabet

A α	Alpha	N ν	Nu
B β	Beta	$\Xi \xi$	Xi, Si
$\Gamma \gamma$	Gamma	O $\omicron$	Omicron
$\Delta \delta$	Delta	$\Pi \pi$	Pi
E ϵ	Epsilon	P ρ	Rho
Z ζ	Zeta	$\Sigma \sigma$	Sigma
H η	Eta	T τ	Tau
$\Theta \theta$	Theta	$\Upsilon \upsilon$	Upsilon
I ι	Iota	$\Phi \phi$	Phi
K κ	Kappa	X χ	Chi
$\Lambda \lambda$	Lambda	$\Psi \psi$	Psi
M μ	Mu	$\Omega \omega$	Omega

Table III Exponential Functions

x	e^x	e^{-x}	x	e^x	e^{-x}
0.0	1.00	1.00	3.0	20.1	.050
0.1	1.11	.905	3.1	22.2	.045
0.2	1.22	.819	3.2	24.5	.041
0.3	1.35	.741	3.3	27.1	.037
0.4	1.49	.670	3.4	30.0	.033
0.5	1.65	.607	3.5	33.1	.030
0.6	1.82	.549	3.6	36.6	.027
0.7	2.01	.497	3.7	40.4	.025
0.8	2.23	.449	3.8	44.7	.022
0.9	2.46	.407	3.9	49.4	.020
1.0	2.72	.368	4.0	54.6	.018
1.1	3.00	.333	4.1	60.3	.017
1.2	3.32	.301	4.2	66.7	.015
1.3	3.67	.273	4.3	73.7	.014
1.4	4.06	.247	4.4	81.5	.012
1.5	4.48	.223	4.5	90.0	.011
1.6	4.95	.202	4.6	99.5	.010
1.7	5.47	.183	4.7	110	.0091
1.8	6.05	.165	4.8	122	.0082
1.9	6.69	.150	4.9	134	.0074
2.0	7.39	.135	5.0	148	.0067
2.1	8.17	.122	5.1	164	.0061
2.2	9.02	.111	5.2	181	.0055
2.3	9.97	.100	5.3	200	.0050
2.4	11.0	.091	5.4	221	.0045
2.5	12.2	.082	5.5	245	.0041
2.6	13.5	.074	5.6	270	.0037
2.7	14.9	.067	5.7	299	.0033
2.8	16.4	.061	5.8	330	.0030
2.9	18.2	.055	5.9	365	.0027
			6.0	403	.0025

Table IV Natural Logarithms

n	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0*		7.697	8.391	8.796	9.084	9.307	9.489	9.643	9.777	9.895
1	0.000	0.095	0.182	0.262	0.336	0.405	0.470	0.531	0.588	0.642
2	0.693	0.742	0.788	0.833	0.875	0.916	0.956	0.993	1.030	1.065
3	1.099	1.131	1.163	1.194	1.224	1.253	1.281	1.308	1.335	1.361
4	1.386	1.411	1.435	1.459	1.482	1.504	1.526	1.548	1.569	1.589
5	1.609	1.629	1.649	1.668	1.686	1.705	1.723	1.740	1.758	1.775
6	1.792	1.808	1.825	1.841	1.856	1.872	1.887	1.902	1.917	1.932
7	1.946	1.960	1.974	1.988	2.001	2.015	2.028	2.041	2.054	2.067
8	2.079	2.092	2.104	2.116	2.128	2.140	2.152	2.163	2.175	2.186
9	2.197	2.208	2.219	2.230	2.241	2.251	2.262	2.272	2.282	2.293
10	2.303	2.313	2.322	2.332	2.342	2.351	2.361	2.370	2.380	2.389

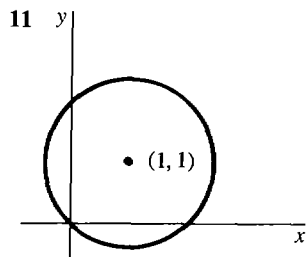
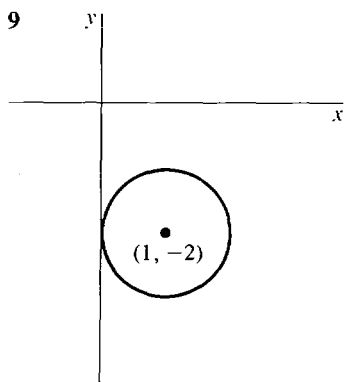
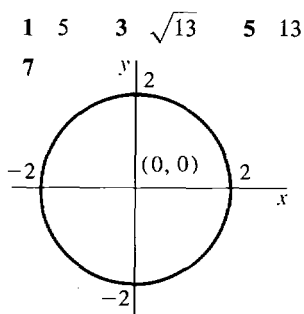
* Subtract 10 if $n < 1$; for example, $\ln 0.3 \approx 8.796 - 10 = -1.204$.

Table V Powers and Roots

n	n^2	$\sqrt{n}$	n^3	$\sqrt[3]{n}$	n	n^2	$\sqrt{n}$	n^3	$\sqrt[3]{n}$
1	1	1.000	1	1.000	51	2,601	7.141	132,651	3.708
2	4	1.414	8	1.260	52	2,704	7.211	140,608	3.733
3	9	1.732	27	1.442	53	2,809	7.280	148,877	3.756
4	16	2.000	64	1.587	54	2,916	7.348	157,464	3.780
5	25	2.236	125	1.710	55	3,025	7.416	166,375	3.803
6	36	2.449	216	1.817	56	3,136	7.483	175,616	3.826
7	49	2.646	343	1.913	57	3,249	7.550	185,193	3.849
8	64	2.828	512	2.000	58	3,364	7.616	195,112	3.871
9	81	3.000	729	2.080	59	3,481	7.681	205,379	3.893
10	100	3.162	1,000	2.154	60	3,600	7.746	216,000	3.915
11	121	3.317	1,331	2.224	61	3,721	7.810	226,981	3.936
12	144	3.464	1,728	2.289	62	3,844	7.874	238,328	3.958
13	169	3.606	2,197	2.351	63	3,969	7.937	250,047	3.979
14	196	3.742	2,744	2.410	64	4,096	8.000	262,144	4.000
15	225	3.873	3,375	2.466	65	4,225	8.062	274,625	4.021
16	256	4.000	4,096	2.520	66	4,356	8.124	287,496	4.041
17	289	4.123	4,913	2.571	67	4,489	8.185	300,763	4.062
18	324	4.243	5,832	2.621	68	4,624	8.246	314,432	4.082
19	361	4.359	6,859	2.668	69	4,761	8.307	328,509	4.102
20	400	4.472	8,000	2.714	70	4,900	8.367	343,000	4.121
21	441	4.583	9,261	2.759	71	5,041	8.426	357,911	4.141
22	484	4.690	10,648	2.802	72	5,184	8.485	373,248	4.160
23	529	4.796	12,167	2.844	73	5,329	8.544	389,017	4.179
24	576	4.899	13,824	2.884	74	5,476	8.602	405,224	4.198
25	625	5.000	15,625	2.924	75	5,625	8.660	421,875	4.217
26	676	5.099	17,576	2.962	76	5,776	8.718	438,976	4.236
27	729	5.196	19,683	3.000	77	5,929	8.775	456,533	4.254
28	784	5.292	21,952	3.037	78	6,084	8.832	474,552	4.273
29	841	5.385	24,389	3.072	79	6,241	8.888	493,039	4.291
30	900	5.477	27,000	3.107	80	6,400	8.944	512,000	4.309
31	961	5.568	29,791	3.141	81	6,561	9.000	531,441	4.327
32	1,024	5.657	32,768	3.175	82	6,724	9.055	551,368	4.344
33	1,089	5.745	35,937	3.208	83	6,889	9.110	571,787	4.362
34	1,156	5.831	39,304	3.240	84	7,056	9.165	592,704	4.380
35	1,225	5.916	42,875	3.271	85	7,225	9.220	614,125	4.397
36	1,296	6.000	46,656	3.302	86	7,396	9.274	636,056	4.414
37	1,369	6.083	50,653	3.332	87	7,569	9.327	658,503	4.431
38	1,444	6.164	54,872	3.362	88	7,744	9.381	681,472	4.448
39	1,521	6.245	59,319	3.391	89	7,921	9.434	704,969	4.465
40	1,600	6.325	64,000	3.420	90	8,100	9.487	729,000	4.481
41	1,681	6.403	68,921	3.448	91	8,281	9.539	753,571	4.498
42	1,764	6.481	74,088	3.476	92	8,464	9.592	778,688	4.514
43	1,849	6.557	79,507	3.503	93	8,649	9.644	804,357	4.531
44	1,936	6.633	85,184	3.530	94	8,836	9.695	830,584	4.547
45	2,025	6.708	91,125	3.557	95	9,025	9.747	857,375	4.563
46	2,116	6.782	97,336	3.583	96	9,216	9.798	884,736	4.579
47	2,209	6.856	103,823	3.609	97	9,409	9.849	912,673	4.595
48	2,304	6.928	110,592	3.634	98	9,604	9.899	941,192	4.610
49	2,401	7.000	117,649	3.659	99	9,801	9.950	970,299	4.626
50	2,500	7.071	125,000	3.684	100	10,000	10.000	1,000,000	4.642

ANSWERS TO SELECTED PROBLEMS

Section 1.1



13 $(x - 3)^2 + y^2 = 4$

15 $(x - 1)^2 + (y - \sqrt{3})^2 = 4, (x - 1)^2 + (y + \sqrt{3})^2 = 4$

17 $(x - 2)^2 + (y - 4)^2 = 25$

Section 1.2

	-1	$-\frac{1}{2}$	0	$\frac{1}{2}$	1
1	-1/3	-1/6	0	1/6	1/3
3	-6	3/8	2	9/8	0
5	1	$1/\sqrt{2}$	0	*	*
7	2	1	1	1	2

9 yes

$$11 \quad f(2) = 7, f(t) = 1 + t + t^2, f(t + \Delta t) = 1 + (t + \Delta t) + (t + \Delta t)^2, \\ f(1 + t + t^2) = 1 + (1 + t + t^2) + (1 + t + t^2)^2, f(g(t)) = 1 + g(t) + (g(t))^2$$

$$13 \quad f(t) = t\sqrt{t}, f(t + \Delta t) = (t + \Delta t)^{3/2}, f(t^2) = |t^3|, f(\sqrt{t}) = t^{3/4}, f(g(t)) = (g(t))^{3/2}$$

$$15 \quad 4\Delta x$$

$$17 \quad \frac{1}{x^2 + 2x\Delta x + \Delta x^2} - \frac{1}{x^2} = -\frac{(2x + \Delta x)\Delta x}{x^2(x^2 + 2x\Delta x + \Delta x^2)}$$

$$19 \quad \sqrt{x + \Delta x} - \sqrt{x} = \frac{\Delta x}{\sqrt{x + \Delta x} + \sqrt{x}}$$

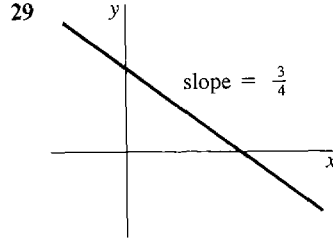
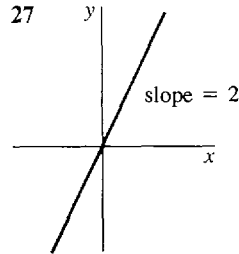
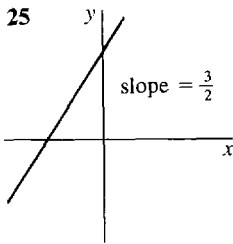
$$21 \quad \text{everywhere except } x = 1 \text{ and } x = -1 \quad 23 \quad x \geq 0 \quad 25 \quad (-1, 1)$$

Section 1.3

$$1 \quad m = 1, y = x + 1 \quad 3 \quad \text{vertical, } x = -4 \quad 5 \quad m = -\frac{1}{3}, y = (-\frac{1}{3})x + 1$$

$$7 \quad m = 0, y = 3 \quad 9 \quad y = 2x - 3 \quad 11 \quad y = -(\frac{1}{2})x - \frac{7}{2} \quad 13 \quad y = 5x \quad 15 \quad y = 4$$

$$17 \quad v = 2, y = 2t \quad 19 \quad v = -\frac{1}{2}, y = -(\frac{1}{2})t + \frac{9}{2} \quad 21 \quad v = 0, y = 4 \quad 23 \quad y = 3t + 2$$



$$33 \quad (-c/a, 0), (0, -c/b)$$

Section 1.4 (no problem set)

Section 1.5

- 1 infinitesimal 3 infinite 5 infinite 7 infinite 9 infinitesimal
 11 infinitesimal 13 infinite 15 infinite 17 finite 19 finite 21 infinite
 23 infinitesimal 25 infinite 27 finite 29 finite 31 finite 33 infinite
 35 infinitesimal 37 infinite 39 finite

$$41 \quad (a) \varepsilon > \varepsilon^2 \quad (b) 1/\varepsilon^3 < 1/\varepsilon^4 \quad (c) H < H^2 \quad (d) \varepsilon < \sqrt{\varepsilon} \quad (e) H > \sqrt{H} \quad (f) \sqrt{H} > \sqrt[3]{H}$$

$$43 \quad (a) a = 0 \text{ and } b \neq 0 \quad (b) a \neq 0 \text{ and } b \neq 0, \text{ or } a = b = 0 \quad (c) a \neq 0 \text{ and } b = 0$$

Section 1.6

$$1 \quad 2 \quad 3 \quad 2/5 \quad 5 \quad x^{12} \quad 7 \quad 0 \quad 9 \quad 2 \quad 11 \quad 3 \quad 13 \quad 0 \quad 15 \quad 1/2 \quad 17 \quad 1/2$$

$$19 \quad x + y \quad 21 \quad 3x^2 \quad 23 \quad 10 \quad 25 \quad -1/6 \quad 27 \quad 1 \quad 29 \quad 1/2 \quad 31 \quad -1/16$$

$$33 \quad \frac{1}{1 + \sqrt{2}} \text{ or } \sqrt{2} - 1$$

Extra Problems for Chapter 1.

- 1 $\sqrt{122}$ 3 $-5/3$ 5 $y = -2x + 13$ 7 $(x - 1)^2 + (y - 3)^2 = 5$
 9 finite 11 infinite 13 infinite 15 infinitesimal 17 48
 19 $4/7$ 21 $-15/4$ 23 $\frac{1}{\sqrt{x + \Delta x}} - \frac{1}{\sqrt{x}}$

Section 2.1

- 1 $2x$ 3 $-4x$ 5 4 7 $12t^2$ 9 $5/(2\sqrt{u})$ 11 $\frac{3}{2}\sqrt{x}$ 13 $-2t^{-3}$
 15 $-3y^{-2} + 4$ 17 a 19 $a/(2\sqrt{ax + b})$ 21 $2(3 - 2x)^{-2}$ 23 $1/4$ 25 $4t^3$
 27 \$600, \$0, $-\$1000$ 29 $-3x^2$ if $x \leq 0$, $3x^2$ if $x > 0$.

Section 2.2

- 1 $\Delta y = 2x \Delta x + \Delta x^2$, $dy = 2x \Delta x$, $\Delta y = dy + \Delta x^2$
 3 $\Delta y = \frac{2 \Delta x}{\sqrt{x + \Delta x} + \sqrt{x}}$, $dy = \frac{\Delta x}{\sqrt{x}}$, $\Delta y = dy + \left[\frac{2}{\sqrt{x + \Delta x} + \sqrt{x}} - \frac{1}{\sqrt{x}} \right] \Delta x$
 5 $\Delta y = -\frac{\Delta x}{x(x + \Delta x)}$, $dy = -\frac{\Delta x}{x^2}$, $\Delta y = dy + \left[\frac{1}{x^2} - \frac{1}{x(x + \Delta x)} \right] \Delta x$
 7 $\Delta y = \left(1 + \frac{1}{x(x + \Delta x)} \right) \Delta x$, $dy = \left(1 + \frac{1}{x^2} \right) \Delta x$, $\Delta y = dy + \left[\frac{1}{x(x + \Delta x)} - \frac{1}{x^2} \right] \Delta x$
 9 $\Delta y = 4x \Delta x + 2 \Delta x^2$, $\Delta z = 3x^2 \Delta x + 3x \Delta x^2 + \Delta x^3$, $dy = 4x dx$, $dz = 3x^2 dx$ 11 $2 dx$
 13 $dx/(2\sqrt{x + 1})$ 15 $a dx$ 17 $(-2/x^2) dx$ 19 $-\frac{1}{2}x^{-3/2} dx$
 21 $d(y + z) = \left(\frac{1}{2\sqrt{x}} + 3 \right) dx$, $d\left(\frac{y}{z}\right) = -\frac{1}{6}x^{-3/2} dx$ 23 $y = 4x - 4$ 25 $y = 0$
 27 $y = 3x - 4$ 29 $y = -32x - 48$ 31 $y = (2x_0)x - x_0^2$

Section 2.3

- 1 $6x + 5$ 3 $5(x + 8)^4$ 5 $-3(4 - t)^2$ 7 $6x(x^2 + 5)^2$ 9 $-12x(6 - 2x^2)^2$
 11 $24x^2(1 - 4x^3)^{-3}$ 13 $5(1 + x^{-2})$ 15 $-8(4x - 1)(2x^2 - x + 3)^{-3}$
 17 $t^{-2}(1 + t^{-1})^{-2}$ or $(t + 1)^{-2}$ 19 $3(8t - 2)(4t^2 - 2t + 1)^{-2}$ 21 $-3x^2 + 5x - 1$
 23 $6(3t^2 + 1)(2t - 4)^2 + 6t(2t - 4)^3$ or $6(2t - 4)^2(5t^2 - 4t + 1)$ 25 $-2(x - 1)^{-2}$
 27 $4x(x^2 + 1)^{-2}$ 29 $(s^2 - 6s + 7)(s - 3)^{-2}$ 31 $-5(3x - 4)^{-2}$ 33 0
 35 $6(x^2 + 1)(2x^2 - 1) + 12x(x^2 + 1)(2x + 3) + 6x(2x^2 - 1)(2x + 3)$
 37 $-(4x - 5)(2x + 1)^{-2}(x - 3)^{-2}$ 39 $2(2x + 1)^{-2}[(2x + 1)^{-1} + 3]^{-2}$
 41 $4x(2x + 1)^3(x^2 + 1) + 6(2x + 1)^2(x^2 + 1)^2$ or $2(2x + 1)^2(x^2 + 1)(7x^2 + 2x + 3)$
 43 $\frac{dy}{dx} = \frac{du}{dx} - \frac{dv}{dx}$ 45 $\frac{dy}{dx} = 4 \frac{du}{dx} + 2v \frac{dv}{dx}$ 47 $\frac{dy}{dx} = - \left[u \frac{dv}{dx} + v \frac{du}{dx} \right] (uv)^{-2}$
 49 $y = 6x - 2$ 51 $b = -2$, $c = 4$

Section 2.4

- 1 $(9y^2 + 2)^{-1}$ 3 $-\frac{1}{4}y^{-1}$ 5 $-\frac{1}{2}y^{-1}(y^2 + 2)^2$ or $-1/(2x^2y)$ 7 $\frac{4}{3}x^{1/3}$
 9 $-\frac{1}{\sqrt{x}(\sqrt{x} - 1)^2}$ 11 $\frac{2}{3}x^{-2/3} + \frac{8}{3}x^{-1/3} + 6$ 13 $-2(\frac{2}{3}x^{2/3} - 1)(x^{5/3} - x)^{-3}$
 15 $(y^{-2/3} + 2)^{-1}$ 17 $y = \frac{1}{k}(x - c)$, $\frac{dy}{dx} = \frac{1}{k}$ 19 $y = \sqrt{\frac{x - 1}{2}}$, $\frac{dy}{dx} = \frac{1}{2\sqrt{2}\sqrt{x - 1}}$
 21 $y = (x + 3)^{1/4}$, $\frac{dy}{dx} = \frac{1}{4}(x + 3)^{-3/4}$

$$\begin{aligned}
 23 \quad y &= \left[\frac{\sqrt{4x-3}-1}{2} \right]^{1/2}, \frac{dy}{dx} = (4y^3 + 2y)^{-1} \text{ or } \frac{dy}{dx} = \frac{1}{2} \left[\frac{\sqrt{4x-3}-1}{2} \right]^{-1/2} (4x-3)^{-1/2} \\
 25 \quad y &= \left[\frac{\sqrt{1+8x}-1}{4} \right]^2 = \frac{1+4x-\sqrt{1+8x}}{8}, \frac{dy}{dx} = \left(\frac{1}{2\sqrt{y}} + 2 \right)^{-1} \\
 &\text{or } \frac{dy}{dx} = \frac{1}{2} - \frac{1}{2\sqrt{1+8x}}
 \end{aligned}$$

Section 2.5

$$\begin{aligned}
 1 \quad &-2 \sin \theta \cos \theta & 3 \quad &2 \cos x - 3 \sin x & 5 \quad &\sin z (\cos z)^{-2} & 7 \quad &n \sin^{n-1} \theta \cos \theta \\
 9 \quad &t \cos t + \sin t & 11 \quad &e^x + x e^x & 13 \quad &(2 \ln x)/x & 15 \quad &e^x/x + e^x \ln x \\
 17 \quad &-e^v \sqrt{v} + (1 - e^v)/2\sqrt{v} & 19 \quad &x^n/x + n x^{n-1} \ln x \\
 21 \quad &y - 1/2 = (\sqrt{3}/2)(x - \pi/6) & 23 \quad &y = x - x/e
 \end{aligned}$$

Section 2.6

$$\begin{aligned}
 1 \quad &\frac{1}{2}(x+2)^{-1/2} & 3 \quad &-\frac{1}{2}(5-x)^{-1/2} & 5 \quad &-\frac{3}{2}(2+3x)^{-3/2} & 7 \quad &2(6x+1)^{-2/3} \\
 9 \quad &x(x^2+1)^{-1/2} & 11 \quad &3 \cos(3x) & 13 \quad &-2x^{-3} \cos(x^{-2}) & 15 \quad &4e^{4x} \\
 17 \quad &-\sin x e^{\cos x} & 19 \quad &-e^x \sin(e^x) & 21 \quad &-40(1-4x)^9 \\
 23 \quad &-2x \cos(1-x^2) + 2 \cos(2x-1) \\
 25 \quad &\frac{e^{\sqrt{\sin x}} \cos x}{2\sqrt{\sin x}} & 27 \quad &-\frac{1}{3}x(1+\sqrt{x^2-1})^{-4/3}(x^2-1)^{-1/2} \\
 29 \quad &-12[1+(x^3+1)^{-1}]^3 x^2 (x^3+1)^{-2} \\
 31 \quad &\frac{1}{3}[\sqrt{x^2-1} + \sqrt{x^2+1}]^{-2/3} [x(x^2-1)^{-1/2} + x(x^2+1)^{-1/2}] \\
 33 \quad &6x \cos(2x-1) + 3 \sin(2x-1) \\
 35 \quad &-\frac{\cos(3t)}{\sin(3t)} & 37 \quad &\frac{2 \cos(2t)}{\cos t} \\
 39 \quad &2t(t+1) & 41 \quad &\sqrt{t^2-4}/\sqrt{t^2+4} \\
 43 \quad &(t+1)^{2/3}(t+2)^{-2/3} & 45 \quad &(9/2)t
 \end{aligned}$$

Section 2.7

$$\begin{aligned}
 1 \quad &2x^{-3} & 3 \quad &-10(x+1)^{-3} & 5 \quad &-(1/4)x^{-3/2} + (3/4)x^{-5/2} & 7 \quad &(3/4)t^{-1/2} \\
 9 \quad &-\sin x & 11 \quad &-AB^2 \sin(Bx) & 13 \quad &a^2 e^{ax} & 15 \quad &-x^{-2} \\
 17 \quad &-2(t^2+1)^{-2} + 8t^2(t^2+1)^{-3} & 19 \quad &-14(x+2)^{-3} \\
 21 \quad &-\frac{1}{4}x(x+1)^{-3/2} + (x+1)^{-1/2} \text{ or } (\frac{3}{4}x+1)(x+1)^{-3/2} \\
 23 \quad &\frac{3}{4}t^{1/2}(t+3)^{-5/2} - \frac{1}{2}t^{-1/2}(t+3)^{-3/2} - \frac{1}{4}t^{-3/2}(t+3)^{-1/2} \text{ or } -(3t^{-1/2} + \frac{9}{4}t^{-3/2})(t+3)^{-5/2} \\
 25 \quad &-6t^{-4} & 27 \quad &3 \frac{d^2u}{dx^2} & 29 \quad &2u \frac{d^2u}{dx^2} + 2 \left(\frac{du}{dx} \right)^2
 \end{aligned}$$

Section 2.8

$$\begin{aligned}
 1 \quad &-(y/x) & 3 \quad &-(x/y)^2 & 5 \quad &\frac{-y}{2y+x} & 7 \quad &-(y/x)^3 & 9 \quad &-\frac{2x+3y}{3x+2y} & 11 \quad &\frac{5x^4}{2y-1} \\
 13 \quad &\frac{y}{2y-x} & 15 \quad &\frac{6xy-y^2-1}{2xy-3x^2} & 17 \quad &\frac{y \cos(xy)}{1-x \cos(xy)} & 19 \quad &-\frac{1}{2 \sin y \cos y} \\
 21 \quad &\frac{y}{1-2y} & 23 \quad &ye^x & 25 \quad &2(6y^2+4xy-3)^{-1}
 \end{aligned}$$

- 27 at (1, 2), $y' = -4/5$; at (-1, 3), $y' = -1/5$
 29 at (2, 1), $y' = 2$; at (2, -1), $y' = -2$; at $(\sqrt{3}, 0)$, vertical
 31 $-2/3$ 33 e 35 $\frac{2x}{y}, \frac{2y^2 - 4x^2}{y^3}$

Extra Problems for Chapter 2

- 1 $12x^2 - 2$ 3 8 5 $\Delta y = \frac{1}{(x + \Delta x)^3} - \frac{1}{x^3} = -\frac{3x^2 + 3x\Delta x + \Delta x^2}{x^3(x + \Delta x)^3}\Delta x$,
 $dy = -3x^{-4}\Delta x$ 7 $(2x - 2x^{-3})dx$ 9 $y = -x$ 11 $-9x^2 - 5$
 13 $9t^2 + 8t - 15$ 15 $(-2v^4 + 10v^3 - 3v^2 - 16v + 20)(v^3 - 4)^{-2}$
 17 $\frac{1}{2}x^{-1/2} + 6x^{1/2}$ 19 $\frac{1}{3}x^{-2/3} + \frac{1}{4}x^{-5/4}$ 21 $(2y + \frac{1}{2}y^{-1/2})^{-1}$ or $\frac{2\sqrt{y}}{4y\sqrt{y} + 1}$
 23 $\frac{-3}{2\sqrt{1-3x}}$ 25 $-\frac{5}{2}(5x + 4)^{-3/2}$ 27 $-(3 + \frac{1}{2}t^{-1/2})(t^{-2} + 2t)^{-1}$
 29 $-4(4x - 1)^{-3/2}$ 31 $v = \frac{3t + 6}{2\sqrt{t + 3}}, a = \frac{3t + 12}{4(t + 3)^{3/2}}$ 33 $-\frac{3y^3 + 6x^2y}{9xy^2 + 2x^3}$
 35 $f'(x) = \begin{cases} 2x & \text{if } |x| > 1 \\ \text{undefined} & \text{if } |x| = 1 \\ -2x & \text{if } |x| < 1 \end{cases}$

Section 3.1

- 1 $p = 4\sqrt{A}$ 3 $V = S^{3/2}/(6\sqrt{\pi})$ 5 $z = \sqrt{x^4 - x^2 + 1}$ 7 $V = (s - 2x)^2x$
 9 $s = 3y/(10 - y)$, $0 < y < 10$ 11 $b/16$ 13 $A = (1 + t)(w - 2t)$
 15 $P(x) = x(100 - \sqrt{x}) - 10x$ or $P(x) = x(90 - \sqrt{x})$

Section 3.2

- 1 $100 \text{ cm}^2/\text{sec}$ 3 $-2 \text{ in.}^2/\text{sec}$ 5 $10\sqrt{61} \text{ mph}$ 7 $10/3 \text{ in.}^2/\text{sec}$
 9 $40(3g)^{1/2} \text{ ft/sec}$ where $g = 32$, or $160\sqrt{6} \text{ ft/sec}$ 11 -120 mph
 13 $\frac{800 \cdot 400}{\sqrt{(800)^2 + 6^2}} = \frac{160,000}{\sqrt{160,009}} \text{ mph}$ 15 -2 ft/sec
 17 $1,000,000t - 300,000\sqrt{t} \text{ people/year}$ 19 $\$60 \text{ per person per year}$
 21 $(55/144)\pi \text{ in.}^2/\text{min}$ 23 -0.01 25 $2 - (x/500)$ 27 -100 radians/hr
 29 22

Section 3.3

- 1 53 3 does not exist 5 does not exist 7 $-1/(4\sqrt{2})$ 9 $1/3$
 11 does not exist 13 does not exist 15 1 17 $(1 + \sqrt{2})^{1/2}$ 19 1
 21 $-1/2$ 23 $2x$ 25 $1/(2\sqrt{t})$ 27 $3x^2$ 29 -2 31 does not exist

Section 3.4

- 1 R 3 > -2 5 R 7 all x except $x = 0, x = -1$ 9 $-2 < x < 2$
 11 all x except $x = (-1 \pm \sqrt{5})/2$ and $x = -1$
 13 all x except $x = 2, x = 3$ 15 $x < i$

Section 3.5

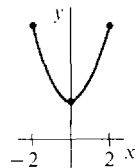
- 1 0, min 3 0, min 5 0, neither 7 $-1/3$, min 9 0, min 11 0, max
 13 0, neither 15 $-1/(2^{1/3})$, min 17 $3/2$, min 19 0, max 21 π , neither
 23 0, max 25 0, min 27 -1 , min 29 1, min 31 3, min 33 0, max
 35 $1/2$, max 37 $1/\sqrt{17}$ at $(4/17, 1/17)$ 39 $1 - m$ at $x = 1$
 41 max of $3/4$ at $x = 2$, min of $-1/4$ at $x = -2$
 43 max of $3/(4 \cdot 3^{1/4})$ at $x = 1/(3^{1/4})$, min of $-3/(4 \cdot 3^{1/4})$ at $x = -1/(3^{1/4})$

Section 3.6

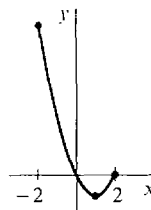
- 1 $x = 20/3, y = 40/3$ 3 $x = 50, y = 1$ 5 $x = 3/4, y = 1/4, x^3y = 27/256$
 7 width = $10\sqrt{3}$ in., length = $40\sqrt{3}$ in. 9 base = height = $1/\sqrt{2}$
 11 side of square = $10/3$ in., height of triangle = $10/3$ in. 13 area = r^2
 15 base of radius $2/3$, height 1 17 base of radius $4/(3\pi)$, height $4/3$ 19 50
 21 $x = 50,000, p = \$5$ 23 256 sec 25 $1/2$ 27 base 4, height 2
 29 $1/\sqrt{17}$ at $x = 4/17, y = 1/17$ 31 height $(3/2) \cdot \text{side of base}$
 33 $r = (2\pi)^{-1/3}, h = (4/\pi)^{1/3}$ 35 $x = (a + b)/2$
 37 $A = 2/r, dA/dr$ is never zero, $0 < r < \infty$ 39 $10\sqrt[3]{2}$ hours 41 62,500

Section 3.7

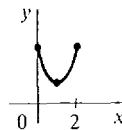
1	x	$f(x)$	$f'(x)$	$f''(x)$		
	-2	6	-4	+	decr.	$\cup$
	0	2	0	+	min.	$\cup$
	2	6	4	+	incr.	$\cup$



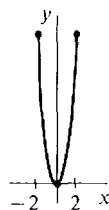
3	x	$f(x)$	$f'(x)$	$f''(x)$		
	-2	8	-6	+	decr.	$\cup$
	1	-1	0	+	min.	$\cup$
	2	0	2	+	incr.	$\cup$



5	x	$f(x)$	$f'(x)$	$f''(x)$		
	0	3	-4	+	decr.	$\cup$
	1	1	0	+	min.	$\cup$
	2	3	4	+	incr.	$\cup$

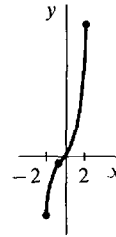


7	x	$f(x)$	$f'(x)$	$f''(x)$		
	-2	16	-32	+	decr.	$\cup$
	0	0	0	+	min.	$\cup$
	2	16	32	+	incr.	$\cup$



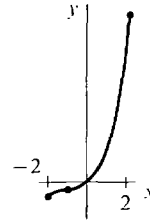
9

x	$f(x)$	$f'(x)$	$f''(x)$		
-2	-6	9	-	incr.	$\cap$
$-\frac{1}{3}$	$-\frac{7}{27}$	$\frac{2}{3}$	0	incr.	infl.
2	14	17	+	incr.	$\cup$



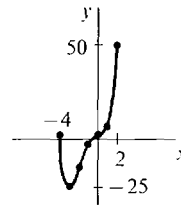
11

x	$f(x)$	$f'(x)$	$f''(x)$		
-2	$-\frac{2}{3}$	1	-	incr.	$\cap$
-1	$-\frac{1}{3}$	0	0	horiz.	infl.
2	$8\frac{2}{3}$	9	+	incr.	$\cup$



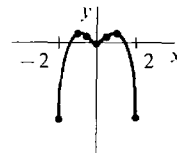
13

x	$f(x)$	$f'(x)$	$f''(x)$		
-4	2	-64	+	decr.	$\cup$
-3	-25	0	+	min.	$\cup$
-2	-14	16	0	incr.	infl.
-1	-1	8	-	incr.	$\cap$
0	2	0	0	horiz.	infl.
1	7	16	+	incr.	$\cup$
2	50	96	+	incr.	$\cup$



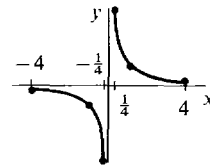
15

x	$f(x)$	$f'(x)$	$f''(x)$		
-2	-4	12	-	incr.	$\cap$
-1	$\frac{1}{2}$	0	-	max.	$\cap$
$-1/\sqrt{3}$	$\frac{5}{18}$	$-\frac{4}{3}\sqrt{3}$	0	decr.	infl.
0	0	0	+	min.	$\cup$
$1/\sqrt{3}$	$\frac{5}{18}$	$\frac{4}{3}\sqrt{3}$	0	incr.	infl.
1	$\frac{1}{2}$	0	-	max.	$\cap$
2	-4	-12	-	decr.	$\cap$



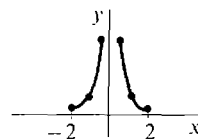
17

x	$f(x)$	$f'(x)$	$f''(x)$		
-4	$-\frac{1}{4}$	$-\frac{1}{16}$	-	decr.	$\cap$
-1	-1	-1	-	decr.	$\cap$
$-\frac{1}{4}$	-4	-16	-	decr.	$\cap$
$\frac{1}{4}$	4	-16	+	decr.	$\cup$
1	1	-1	+	decr.	$\cup$
4	$\frac{1}{4}$	$-\frac{1}{16}$	+	decr.	$\cup$



19

x	$f(x)$	$f'(x)$	$f''(x)$		
-2	$\frac{1}{4}$	$\frac{1}{4}$	+	incr.	$\cup$
-1	1	2	+	incr.	$\cup$
$-\frac{1}{2}$	4	16	+	incr.	$\cup$
$\frac{1}{2}$	4	-16	+	decr.	$\cup$
1	1	-2	+	decr.	$\cup$
2	$\frac{1}{4}$	$-\frac{1}{4}$	+	decr.	$\cup$



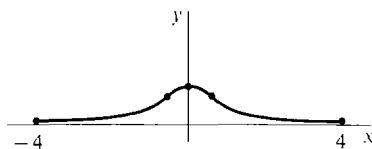
21

x	$f(x)$	$f'(x)$	$f''(x)$		
0	-1	2	-	incr.	$\cap$
1	0	$\frac{1}{2}$	-	incr.	$\cap$
10	$\frac{9}{11}$	$\frac{2}{121}$	-	incr.	$\cap$



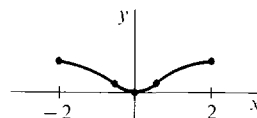
23

x	$f(x)$	$f'(x)$	$f''(x)$		
-4	$\frac{1}{17}$	.03	+	incr.	$\cup$
$-1/\sqrt{3}$	$\frac{3}{4}$	1.9	0	incr.	infl.
0	1	0	-	max.	$\cap$
$1/\sqrt{3}$	$\frac{3}{4}$	-1.9	0	decr.	infl.
4	$\frac{1}{17}$	-.03	+	decr.	$\cup$



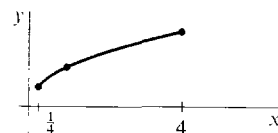
25

x	$f(x)$	$f'(x)$	$f''(x)$		
-2	$\frac{4}{5}$	$-\frac{2}{25}$	-	decr.	$\cap$
$-1/\sqrt{3}$	$\frac{1}{4}$	$-\sqrt{3}/2$	0	decr.	infl.
0	0	0	+	min.	$\cup$
$1/\sqrt{3}$	$\frac{1}{4}$	$\sqrt{3}/2$	0	incr.	infl.
2	$\frac{4}{5}$	$\frac{2}{25}$	-	incr.	$\cap$



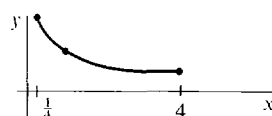
27

x	$f(x)$	$f'(x)$	$f''(x)$		
$\frac{1}{4}$	$\frac{1}{2}$	1	-	incr.	$\cap$
1	1	$\frac{1}{2}$	-	incr.	$\cap$
4	2	$\frac{1}{4}$	-	incr.	$\cap$



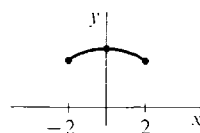
29

x	$f(x)$	$f'(x)$	$f''(x)$		
$\frac{1}{4}$	2	-4	+	decr.	$\cup$
1	1	$-\frac{1}{2}$	+	decr.	$\cup$
4	$\frac{1}{2}$	$-\frac{1}{16}$	+	decr.	$\cup$



31

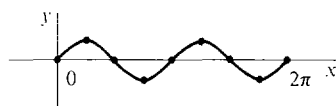
x	$f(x)$	$f'(x)$	$f''(x)$		
-2	$\sqrt{5}$	$2/\sqrt{5}$	-	incr.	$\cap$
0	3	0	-	max.	$\cap$
2	$\sqrt{5}$	$-2/\sqrt{5}$	-	decr.	$\cap$



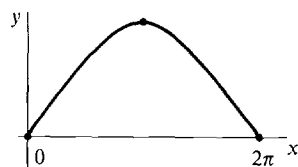
33

x	$f(x)$	$f'(x)$	$f''(x)$		
0	0	1	0	incr.	infl.
$\pi/4$	$\frac{1}{2}$	0	-	max.	$\cap$
$\pi/2$	0	-1	0	decr.	infl.
$3\pi/4$	$-\frac{1}{2}$	0	+	min.	$\cup$
π	0	1	0	incr.	infl.

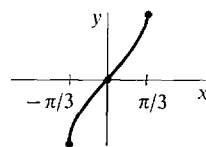
repeats



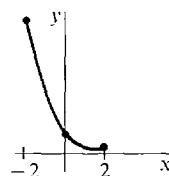
35	x	$f(x)$	$f'(x)$	$f''(x)$		
	0	0	$\frac{3}{2}$	0	incr.	infl.
	π	3	0	-	max.	$\cap$
	2π	0	$-\frac{3}{2}$	0	decr.	infl.



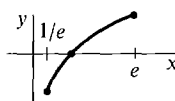
37	x	$f(x)$	$f'(x)$	$f''(x)$		
	$-\pi/3$	$-\sqrt{3}$	4	-	incr.	$\cap$
	0	0	1	0	incr.	infl.
	$\pi/3$	$\sqrt{3}$	4	+	incr.	$\cup$



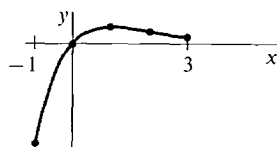
39	x	$f(x)$	$f'(x)$	$f''(x)$		
	-2	e^2	$-e^2$	+	decr.	$\cup$
	0	1	-1	+	decr.	$\cup$
	2	e^{-2}	$-e^{-2}$	+	decr.	$\cup$



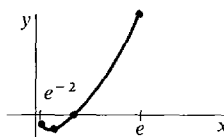
41	x	$f(x)$	$f'(x)$	$f''(x)$		
	$1/e$	-1	e	-	incr.	$\cap$
	1	0	1	-	incr.	$\cap$
	e	1	$1/e$	-	incr.	$\cap$



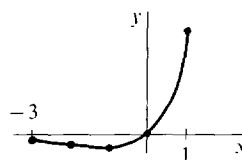
43	x	$f(x)$	$f'(x)$	$f''(x)$		
	-1	$-e$	$2e$	-	incr.	$\cap$
	0	0	1	-	incr.	$\cap$
	1	e^{-1}	0	-	max.	$\cap$
	2	$2e^{-2}$	$-e^{-2}$	0	decr.	infl.
	3	$3e^{-3}$	$-2e^{-3}$	+	decr.	$\cup$



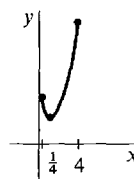
45	x	$f(x)$	$f'(x)$	$f''(x)$		
	e^{-2}	$-2e^{-2}$	-1	e^2	decr.	$\cup$
	e^{-1}	$-e^{-1}$	0	e	min.	$\cup$
	1	0	1	1	incr.	$\cup$
	e	e	2	e^{-1}	incr.	$\cup$



47	x	$f(x)$	$f'(x)$	$f''(x)$		
	-3	$-3e^{-3}$	$-2e^{-3}$	-	decr.	$\cap$
	-2	$-2e^{-2}$	$-e^{-2}$	0	decr.	infl.
	-1	$-e^{-1}$	0	+	min.	$\cup$
	0	0	1	+	incr.	$\cup$
	1	e	$2e$	+	incr.	$\cup$



49	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\frac{1}{4}$	$4e^{\frac{1}{4}}$	$-12e^{\frac{1}{4}}$	+	decr.	$\cup$
	1	e	0	+	min.	$\cup$
	4	$e^4/4$	$\frac{3}{16}e^4$	+	incr.	$\cup$



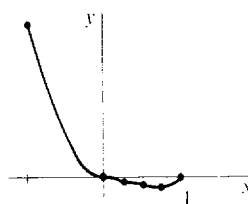
Section 3.8

- 1 $f(0) = 1, f(1) = -1$ 3 $f(4) = 0.236, f(9) = -2.838$
 5 $f(0) = 0.586, f(1) = -0.732$ 7 $f(0) = -1, f(1) = 1$ 9 $f(0) = 1, f(1) = -1$
 11 $f(0) = -1, f(1) = 1$ 13 $f(0) = 0.9, f(\pi) = -1.1$ 15 $f(1) = -1, f(e) = 0.632$
 17 yes 19 yes 21 no 23 yes, $f'(16/7) = 0$ 25 no 27 yes 29 no
 31 one 33 two 35 $1/2$ 37 $8/27$ 39 1 41 $\sqrt{3} - 1$
 43 $f'(x) = 3x^2 - 3$ has no zeros in $(-1, 1)$

Extra Problems for Chapter 3

- 1 $A = 6V^{2/3}$ 3 $x = 300t$ 5 $s = 5x/4$ 7 $16/\pi$ in./sec 9 0.01 in./sec
 11 -3 13 $-1/4$ 15 $-1 < x < 1$ 17 $-2 < x < -1, 1 < x < 2$ 19 none
 21 max = 5 at $x = 1$, min = 3 at $x = 2$ 23 max = 4 at $x = 0$, min = 1 at $x = \pm 1$
 25 square of side $\sqrt{2}$ 27 $8b^3/27a^3$ 29 min = -32 at $x = -2$, no max
 31 base = height = 1 33 three zeros

33	x	$f(x)$	$f'(x)$	$f''(x)$	
	-1	2	-7	+	decr.
	0	0	0	+	horiz.
	$\frac{1}{4}$	$-\frac{3}{256}$	$-\frac{1}{8}$	-	decr.
	$\frac{1}{2}$	$-\frac{1}{16}$	$-\frac{1}{4}$	0	decr.
	$\frac{3}{4}$	$-\frac{27}{256}$	0	+	min.
	1	0	1	+	incr.



- 37 none 39 $f(-1) = \sqrt[3]{7} - 2 < 0, f(0) = 1 > 0$

Section 4.1

- 1 2 3 $5/4$ 5 $11/8$ 7 11 9 $-1/4$ 11 136 13 $901/280 = 3.2$
 15 $177/512 = 0.35$ 17 $1 + \sqrt{2} + \sqrt{3}(\pi - 3) = 2.7$ 19 1.90 21 1.55
 23 3.18

Section 4.2

- 1 $(16/3)x^{3/2}$ 3 $t^3 + t$ 5 $4t - t^3$ 7 $-(7/2)s^{-2}$ 9 $(1/3)(x - 6)^3$
 11 $(2/5)y^{5/2}$ 13 $x^2/2, x \geq 0; -x^2/2, x < 0$ 15 $2/3$ 17 12 19 0
 21 $32/3$ 23 14 25 12 27 9.9 29 $16/3$ 31 $1/6$ 33 2

Section 4.3

- 1 $x + x^2 + x^3 + C$ 3 $(3/2)t^8 - (1/2)t^6 + (2/3)t^3 + t + C$ 5 $(2/3)t^{3/2} + 2t^{1/2} + C$
 7 $(1/6)(2x - 3)^3 + C$ 9 $(1/3)z^3 + 2z - z^{-1} + C$ 11 $5 \sin x + C$
 13 $x + \ln x + C$ 15 $x + 2 \ln x - x^{-1} + C$ 17 $12t - (4/3)t^{3/2} - t^2 + C$
 19 $-4y^{-1} - 6y^{-1/2} + 2\sqrt{y} + C$ 21 $(1/3)ax^3 + (1/2)bx^2 + cx + C$ 23 0
 25 $58/15$ 27 0 29 $3 \ln 2$ 31 $-\ln 3$ 33 $(4/3)t^3 - t + 2$
 35 $-2 \cos t + 12$ 37 $v = (1/2)t^2, y = (1/6)t^3 + 1$
 39 $v = t^3 + 1, y = (1/4)t^4 + t + 2$
 41 $v = -(1/2)t^{-2} + 3/2, y = (1/2)t^{-1} + (3/2)t - 2$ 43 (a), (d), (f), (g), (i), (l)
 45 $y = t^3 + 2t + 1$

Section 4.4

- 1 $-\frac{1}{2(2x+1)} + C$ 3 $-\frac{1}{28}(3-4z)^7 + C$ 5 $-(2/3)(1-t^2)^{3/2} + C$

- 7 $(1/30)(4 + 5x^2)^3 + C$ 9 $-(1/3)\cos(3x) + C$ 11 $-(3/2)\cos(4x - 1) + C$
 13 $(1/2)\sin^2 \theta + C$ 15 $-(1/4)\cos^4 \theta + C$ 17 $-(1/2)\cos(x^2 + 1) + C$
 19 $-\cos(\ln x) + C$ 21 $(2/3)(\sin t)^{3/2} + C$ 23 $(1/2)e^{2x} + C$
 25 $ae^x - be^{-x} + C$ 27 $\frac{1}{2}e^{x^2} + C$ 29 $(b/a)e^{ax} + C$ 31 $e^{\sin \theta} + C$
 33 $\ln(x + 2) + C$ 35 $\ln(e^x + 1) + C$ 37 $x - \ln(x + 1) + C$
 39 $2\ln(1 + \sqrt{x}) + C$ 41 $-3t - 19\ln(5 - t) + C$ 43 $(1/6)(x^4 + 5)^{3/2} + C$
 45 $(1/3)(2 + y^2)^{3/2} + C$ 47 $-(1 - u^2)^{1/2} + C$ 49 $(2/3)(3s + 2)^{1/2} + C$
 51 $-2(1 + x^{-1})^{1/2} + C$ 53 $-(1/15)(3 + 5x^{-2})^{3/2} + C$ 55 $-(2/3)(3 - \sqrt{x})^3 + C$
 57 $-2z^{-1} - (1/2)z^{-2} + C$ 59 $(2/3)(x^3 + 4)^{1/2} + C$ 61 $(1/2)(1 + x^4)^{1/2} + C$
 63 $(2/5)(t + 1)^{5/2} - (2/3)(t + 1)^{3/2} + C$ 65 $(8/3)(1 - s)^{-3} - (1 - s)^{-2} + C$
 67 $-(1/2)(y^2 + 1)^{-1} + (1/4)(y^2 + 1)^{-2} + C$
 69 $(1/24)(4x + 1)^{3/2} - (1/8)(4x + 1)^{1/2} + C$ or $(1/12)(2x - 1)(4x + 1)^{1/2} + C$
 71 $-(2/27)(1 - 3u)^{3/2} + (2/45)(1 - 3u)^{5/2} + C$ 73 $(1/6)(4x + 1)^{3/2} - (4x + 1)^{1/2} + C$
 75 $-(1/4)\ln(1 - x^4) + C$ 77 $(1/4)y^4 - (1/2)y^2 + (1/2)\ln(1 + y^2) + C$ or
 $(1/4)(1 + y^2)^2 - (1 + y^2) + (1/2)\ln(1 + y^2) + C$
 79 $(2/3)\ln(3u + 2) + 3/(3u + 2) + C$ 81 $x - 4\sqrt{x} + 8\ln(2 + \sqrt{x}) + C$
 83 $\ln(\sin \theta) + C$ 85 $(1/b)\ln(a + bx) + C$ 87 $-\ln(1 + \cos \theta) + C$
 89 $(1/2)(\ln x)^2 + C$ 91 $1/2$ 93 $e - e^{-1}$ 95 $\ln 2$ or $(1/2)\ln 4$ 97 $1/2$
 99 $(2/3)(3\sqrt{3} - 1)$ 101 $242/5$ 103 100 105 $(1/6)(17\sqrt{17} - 27)$ 107 0
 109 $(\ln 7 - \ln 4)/3$ 111 $2/3$ 113 $93/35$ 115 0 117 $f(g(x)) + C$

Section 4.5

- 1 $56/3$ 3 2 5 $(10\sqrt{5}/3) - 6$ 7 $32/3$ 9 $500/3$ 11 2 13 4
 15 2 17 $e^2 - 3$ 19 $2(e - e^{-1})$ 21 $2 - \ln 3$ 23 $(3/2) - \ln 2$ 25 $1/5$
 27 $128\sqrt{6}/5$ 29 $4/3$ 31 $32/3$ 33 $1/6$ 35 $19/15$ 37 $49/15$
 39 $23/12$ 41 $3/4$ 43 $1 - (4/3) \cdot 2^{3/4} + (5/6) \cdot 2^{3/5} = 0.02$ 45 $11/4$
 47 $(3 + \sqrt{5})/2$ 49 $\sqrt[3]{54}$ or $3\sqrt[3]{2}$ 51 $c = (1/2)^{2/3}$ or $c = 2^{-2/3}$

Section 4.6

- 1 In all cases, sum = 2, error = 0.
 3 (a) $\Delta x = 0.25$: sum = 1.0426 $\Delta x = 0.1$: sum = 1.0652
 (b) $\Delta x = 0.25$: sum = 1.0594 $\Delta x = 0.1$: sum = 1.0700
 In all cases, there is no error estimate.
 5 (a) $\Delta x = 0.25$: sum = 0.3229, error $\leq 1/384$
 $\Delta x = 0.1$: sum = 0.3220, error $\leq 1/2400$
 (b) $\Delta x = 0.25$: sum = 0.3217108, error $\leq 1/15,360$
 $\Delta x = 0.1$: sum = 0.3217505, error $\leq 1/600,000$
 7 (a) $\Delta x = 0.5$: sum = 2.8968, error $\leq 1/48$
 $\Delta x = 0.1$: sum = 2.9012, error $\leq 1/1200$
 (b) $\Delta x = 0.5$: sum = 2.9013, error $\leq 1/960$
 $\Delta x = 0.1$: sum = 2.901388, error $\leq 1/600,000$
 9 (a) $\Delta x = 0.25$: sum = 1.0968, error $\leq \sqrt{2}/96$
 $\Delta x = 0.1$: sum = 1.0906, error $\leq \sqrt{2}/600$
 (b) $\Delta x = 0.25$: sum = 1.089413
 $\Delta x = 0.1$: sum = 1.089430
 11 (a) $\Delta x = 1$: sum = 2.0214, error ≤ 1
 $\Delta x = 0.1$: sum = 1.9447, error ≤ 0.01
 (b) $\Delta x = 1$: sum = 1.9587, error ≤ 0.8
 $\Delta x = 0.1$: sum = 1.945913, error ≤ 0.0008
 13 (a) $\Delta x = 3$: sum = 1.8793, error $\leq 45/8$
 $\Delta x = 0.1$: sum = 1.6685, error $\leq 5/800$
 (b) $\Delta x = 3$: sum = 1.738132
 $\Delta x = 0.1$: sum = 1.668231

- 15 (a) $\Delta x = \pi/2$: sum = 1.5708, error $\leq \pi^3/48$ or 0.65
 $\Delta x = \pi/10$: sum = 1.9835, error $\leq \pi^3/1200$ or 0.026
 (b) $\Delta x = \pi/2$: sum = 2.0944, error $\leq \pi^5/2880$ or 0.1
 $\Delta x = \pi/10$: sum = 2.00011, error $\leq \pi^5/1,800,000$ or 0.00017
- 17 (a) $\Delta x = 0.25$: sum = 1.7272, error $\leq e/192$ or 0.014
 $\Delta x = 0.1$: sum = 1.7197, error $\leq e/1200$ or 0.002
 (b) $\Delta x = 0.25$: sum = 1.718319, error $\leq e/46,080$ or 0.00006
 $\Delta x = 0.1$: sum = 1.718283, error $\leq e/1,800,000$ or 0.0000015
- 19 (a) $\Delta x = 0.25$: sum = 0.3837, error $\leq 1/192$
 $\Delta x = 0.1$: sum = 0.3859, error $\leq 1/1200$
 (b) $\Delta x = 0.25$: sum = 0.386260, error $\leq 1/46,080$
 $\Delta x = 0.1$: sum = 0.386293, error $\leq 1/1,800,000$

Extra Problems for Chapter 4

- 1 0.6025 3 7.875 5 $1/3$ 7 $76 + 40\sqrt{5}$ 9 $946\frac{2}{3}$ 11 2
 13 $2x + x^2/2 - x^3 + C$ 15 $-(1/4)(x^2 - 1)^{-2} + C$ 17 $-(1/3)(1 - 3u^2)^{1/2} + C$
 19 $(1/3)[(2t + 1)^{3/2} - (2t - 1)^{3/2}] + C$ 21 $(2/5)u^{5/2} - (4/3)u^{3/2} + C$
 23 $2 \sin(x/2) + C$ 25 $-e^{-t} + C$ 27 $40/3$ 29 $(e^4 - 1)/4$ 31 $(x^3 + 2)^{1/2}$
 33 $-\sqrt{u(u-1)^{1/2}}$ 35 $(1/2)x^2 - x + b + 1/2$ 37 $3x^2 - 6x + 5$
 39 $F(x) = 1$ if $x < 0$, $(x^2/2) + 1$ if $x \geq 0$ 43 $\pi ab/2$ 45 $xf(x) + \int_0^x f(t) dt$

Section 5.1

- 1 3 3 ∞ 5 $1/3$ 7 $5/3$ 9 $1/\sqrt{3}$ 11 ∞ 13 ∞ 15 0
 17 $-\infty$ 19 ∞ 21 0 23 $1/2$ 25 $-1/4$ 27 0 29 $-5/6$ 31 0
 33 does not exist 35 ∞ 37 does not exist 39 does not exist 41 ∞
 43 0 45 $-\infty$ 47 $1/2$ 49 ∞ 51 $-3/2$ 53 0 55 1 57 0
 59 does not exist 61 0 63 $-\infty$ 65 does not exist 67 ∞

Section 5.2

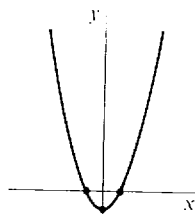
- 1 $1/6$ 3 $1/16$ 5 0 7 $-1/4$ 9 $1/2$ 11 -1 13 5 15 ∞
 17 2 19 3 21 1 23 2 25 1 27 1 29 1 31 1 33 $1/2$
 35 0 37 $1/2$ 39 $1/2$ 41 $4/\sqrt{2} = \sqrt{8}$ 43 2 45 ∞ 47 $3/2$
 49 5 51 does not exist

Section 5.3

- 1 (a) A, B, F, H (b) B, F, H (c) B, F (d) A, B, C, D, F, G, H
 (e) B, D, F, G, H (f) B, D, F

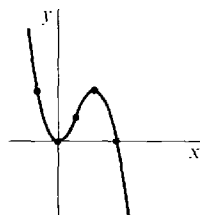
3

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	$-\infty$			
0	0	-2	+	decr.	$\cup$
1	-1	0	+	min.	$\cup$
2	0	2	+	incr.	$\cup$
$\lim_{x \rightarrow \infty}$	∞	∞			



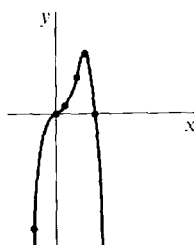
5

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	$-\infty$			
-2	$5\frac{1}{3}$	-6	+	decr.	$\cup$
0	0	0	+	min.	$\cup$
2	$2\frac{2}{3}$	2	0	incr.	infl.
4	$5\frac{1}{3}$	0	-	max.	$\cup$
6	0	-6	-	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	$-\infty$	$-\infty$			



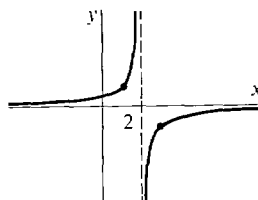
7

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	$-\infty$	∞			
-2	-12	20	-	incr.	$\cup$
0	0	0	0	horiz.	infl.
1	$\frac{3}{4}$	2	+	incr.	$\cup$
2	4	4	0	incr.	infl.
3	$6\frac{3}{4}$	0	-	max.	$\cup$
4	0	-16	-	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	$-\infty$	$-\infty$			



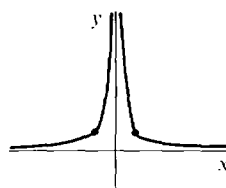
9

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
1	1	1	+	incr.	$\cup$
$\lim_{x \rightarrow 2^-}$	∞	∞			
$\lim_{x \rightarrow 2^+}$	$-\infty$	∞			
3	-1	1	-	incr.	$\cup$
$\lim_{x \rightarrow \infty}$	0	0			



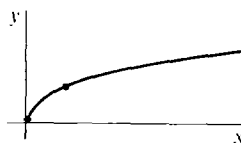
11

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-1	1	2	+	incr.	$\cup$
$\lim_{x \rightarrow 0^-}$	∞	∞			
$\lim_{x \rightarrow 0^+}$	∞	∞			
1	1	-2	+	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	0	0			

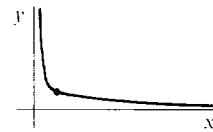


13

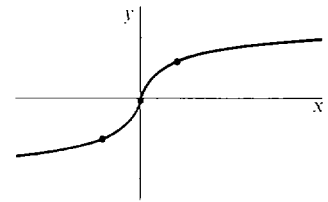
x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow 0^+}$	0	∞			
1	1	$\frac{1}{2}$	-	incr.	$\cup$
$\lim_{x \rightarrow \infty}$	∞	0			



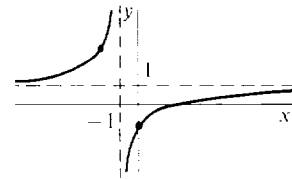
15	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow 0^+}$	∞	$-\infty$			
	1	1	$-\frac{1}{2}$	+	decr.	$\cap$
	$\lim_{x \rightarrow \infty}$	0	0			



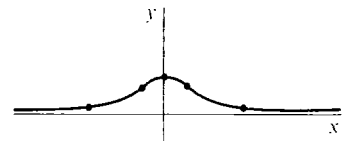
17	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	$-\infty$	0			
	-1	-1	$\frac{1}{3}$	+	incr.	$\cup$
	$\lim_{x \rightarrow 0^-}$	0	∞			
	$\lim_{x \rightarrow 0^+}$	0	∞			
	1	1	$\frac{1}{3}$	-	incr.	$\cap$
	$\lim_{x \rightarrow \infty}$	∞	0			



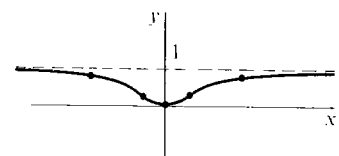
19	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	1	0			
	-2	3	2	-	incr.	$\cap$
	$\lim_{x \rightarrow -1^-}$	∞	∞			
	$\lim_{x \rightarrow -1^+}$	$-\infty$	∞			
	0	-1	2	-	incr.	$\cap$
	$\lim_{x \rightarrow \infty}$	1	0			



21	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	0	0			
	-2	$\frac{1}{5}$	$\frac{4}{25}$	+	incr.	$\cup$
	$-1/\sqrt{3}$	$\frac{3}{4}$	1.9	0	incr.	$\cap$
	0	1	0	-	max.	$\cap$
	$1/\sqrt{3}$	$\frac{3}{4}$	-1.9	0	decr.	$\cup$
	2	$\frac{1}{5}$	$-\frac{4}{25}$	+	decr.	$\cap$
	$\lim_{x \rightarrow \infty}$	0	0			

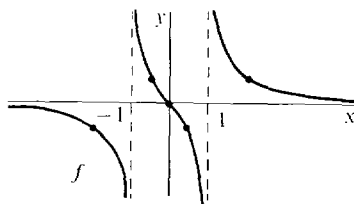


23	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	1	0			
	-2	$\frac{4}{5}$	$-\frac{2}{25}$	-	decr.	$\cap$
	$-1/\sqrt{3}$	$\frac{1}{4}$	$-\sqrt{3}/2$	0	decr.	$\cap$
	0	0	0	+	min.	$\cup$
	$1/\sqrt{3}$	$\frac{1}{4}$	$\sqrt{3}/2$	0	incr.	$\cup$
	2	$\frac{4}{5}$	$\frac{2}{25}$	-	incr.	$\cap$
	$\lim_{x \rightarrow \infty}$	1	0			



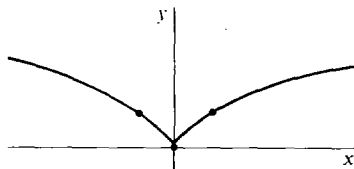
25

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-2	$-\frac{2}{3}$	$-\frac{5}{9}$	-	decr.	$\cap$
$\lim_{x \rightarrow -1^-}$	$-\infty$	$-\infty$			
$\lim_{x \rightarrow -1^+}$	∞	$-\infty$			
$-\frac{1}{2}$	$\frac{2}{3}$	$-\frac{20}{9}$	+	decr.	$\cup$
0	0	-1	0	decr.	infl.
$\frac{1}{2}$	$-\frac{2}{3}$	$-\frac{20}{9}$	-	decr.	$\cap$
$\lim_{x \rightarrow 1^-}$	$-\infty$	$-\infty$			
$\lim_{x \rightarrow 1^+}$	∞	$-\infty$			
2	$\frac{2}{3}$	$-\frac{5}{9}$	+	decr.	$\cup$
∞	0	0			



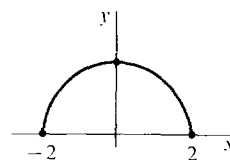
27

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	0			
-1	1	$-\frac{2}{3}$	-	decr.	$\cap$
$\lim_{x \rightarrow 0^-}$	0	$-\infty$		min. (cusp)	
$\lim_{x \rightarrow 0^+}$	0	∞			
1	1	$\frac{2}{3}$	-	incr.	$\cup$
$\lim_{x \rightarrow \infty}$	∞	0			



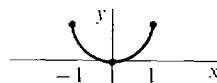
29

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -2^+}$	0	∞			
0	2	0	-	max.	$\cap$
$\lim_{x \rightarrow 2^-}$	0	$-\infty$			



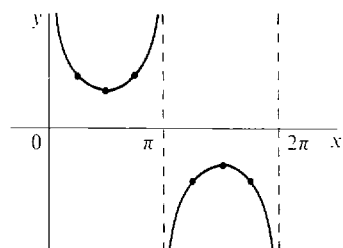
31

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -1^+}$	1	$-\infty$			
0	0	0	+	min.	$\cup$
$\lim_{x \rightarrow 1^-}$	1	∞			



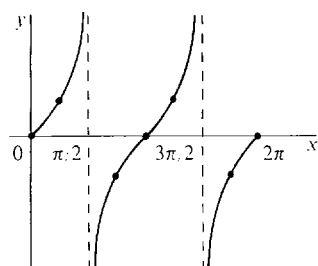
33

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow 0^+}$	∞	$-\infty$			
$\pi/4$	$\sqrt{2}$	$-\sqrt{2}$	+	decr.	$\cup$
$\pi/2$	1	0	+	min.	$\cup$
$3\pi/4$	$\sqrt{2}$	$\sqrt{2}$	+	incr.	$\cup$
$\lim_{x \rightarrow \pi^-}$	∞	∞			
$\lim_{x \rightarrow \pi^+}$	$-\infty$	∞			
$5\pi/4$	$-\sqrt{2}$	$\sqrt{2}$	-	incr.	$\cap$
$3\pi/2$	-1	0	-	max.	$\cap$
$7\pi/4$	$-\sqrt{2}$	$-\sqrt{2}$	-	decr.	$\cap$
$\lim_{x \rightarrow 2\pi^-}$	$-\infty$	$-\infty$			



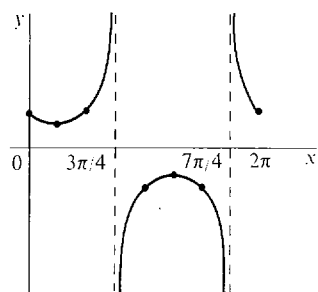
35

x	$f(x)$	$f'(x)$	$f''(x)$		
0	0	1	0	incr.	infl.
$\pi/4$	1	2	+	incr.	$\cup$
$\lim_{x \rightarrow \pi/2^-}$	∞	∞			
$\lim_{x \rightarrow \pi/2^+}$	$-\infty$	∞			
$3\pi/4$	-1	2	-	incr.	$\cap$
π	0	1	0	incr.	infl.
$5\pi/4$	1	2	+	incr.	$\cup$
$\lim_{x \rightarrow 3\pi/2^-}$	∞	∞			
$\lim_{x \rightarrow 3\pi/2^+}$	$-\infty$	∞			
$7\pi/4$	-1	2	-	incr.	$\cap$
2π	0	1	0	incr.	infl.



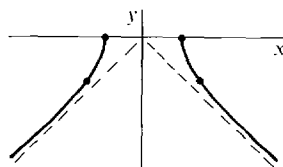
37

x	$f(x)$	$f'(x)$	$f''(x)$		
0	1	-1	+	decr.	$\cup$
$\pi/4$	$\sqrt{2}/2$	0	+	min.	$\cup$
$\pi/2$	1	1	+	incr.	$\cup$
$\lim_{x \rightarrow 3\pi/4^-}$	∞	∞			
$\lim_{x \rightarrow 3\pi/4^+}$	$-\infty$	∞			
π	-1	1	-	incr.	$\cap$
$5\pi/4$	$-\sqrt{2}/2$	0	-	max.	$\cap$
$3\pi/2$	-1	-1	-	decr.	$\cap$
$\lim_{x \rightarrow 7\pi/4^-}$	$-\infty$	$-\infty$			
$\lim_{x \rightarrow 7\pi/4^+}$	∞	$-\infty$			
2π	1	-1	+	decr.	$\cup$



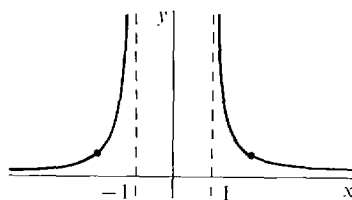
39

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	$-\infty$	1			
-3	$-\sqrt{5}$	$3/\sqrt{5}$	+	incr.	$\cup$
$\lim_{x \rightarrow -2^-}$	0	∞			
$\lim_{x \rightarrow 2^+}$	0	$-\infty$			
3	$-\sqrt{5}$	$-3/\sqrt{5}$	+	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	$-\infty$	-1			



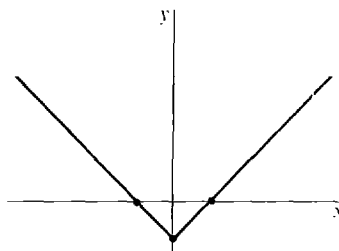
41

x	$f(x)$	$f(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-2	$1/\sqrt{3}$	$2/(3\sqrt{3})$	+	incr.	$\cup$
$\lim_{x \rightarrow -1^-}$	∞	∞			
$\lim_{x \rightarrow 1^+}$	∞	$-\infty$			
2	$1/\sqrt{3}$	$-2/(3\sqrt{3})$	+	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	0	0			



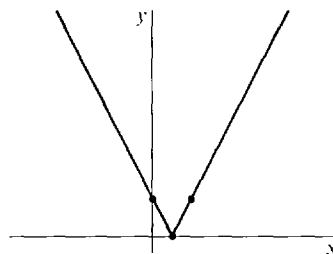
43

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	-1			
-1	0	-1	0	decr.	linear
$\lim_{x \rightarrow 0^-}$	-1	-1		min. (corner)	
$\lim_{x \rightarrow 0^+}$	-1	1			
1	0	1	0	incr.	linear
$\lim_{x \rightarrow \infty}$	∞	1			



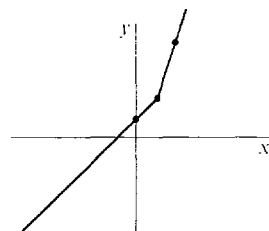
45

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	-2			
0	1	-2	0	decr.	linear
$\lim_{x \rightarrow \frac{1}{2}^-}$	0	-2		min. (corner)	
$\lim_{x \rightarrow \frac{1}{2}^+}$	0	2			
1	1	2	0	incr.	linear
$\lim_{x \rightarrow \infty}$	∞	2			



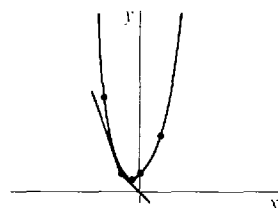
47

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	$-\infty$	1			
0	2	1	0	incr.	linear
$\lim_{x \rightarrow 2^-}$	4	1		corner	
$\lim_{x \rightarrow 2^+}$	4	3			
4	10	3	0	incr.	linear
$\lim_{x \rightarrow \infty}$	∞	3			



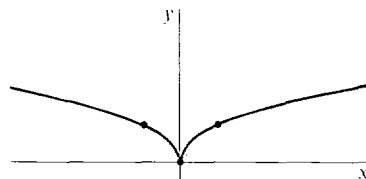
49

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	$-\infty$			
-2	5	-5	2	decr.	$\cup$
$\lim_{x \rightarrow -1^-}$	1	-3		corner	
$\lim_{x \rightarrow -1^+}$	1	-1			
$-\frac{1}{2}$	$\frac{3}{4}$	0	2	min.	$\cup$
0	1	1	2	incr.	$\cup$
1	3	3	2	incr.	$\cup$
$\lim_{x \rightarrow \infty}$	∞	∞			



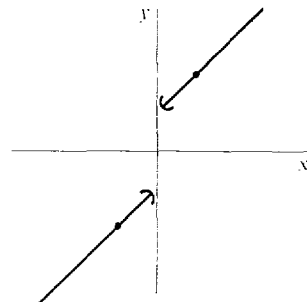
51

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	∞	0			
-1	1	$-\frac{1}{2}$	-	decr.	$\cap$
$\lim_{x \rightarrow 0^-}$	0	$-\infty$		min. (cusp)	
$\lim_{x \rightarrow 0^+}$	0	∞			
1	1	$\frac{1}{2}$	-	incr.	$\cap$
$\lim_{x \rightarrow \infty}$	∞	0			

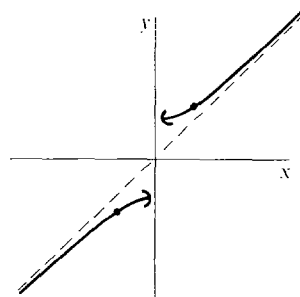


53

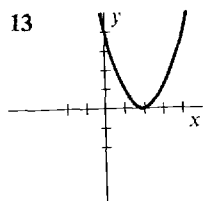
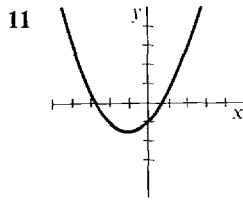
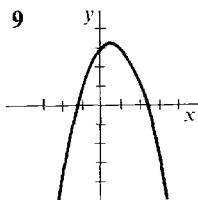
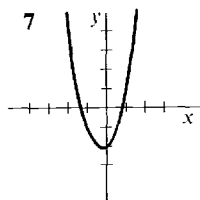
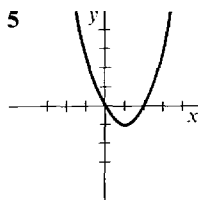
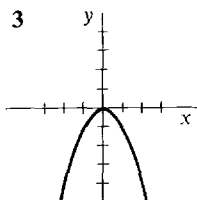
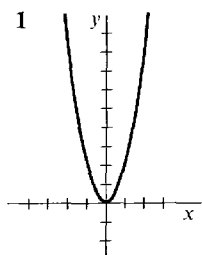
x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	$-\infty$	1			
-1	-2	1	0	incr.	linear
$\lim_{x \rightarrow 0^-}$	-1	1		jump	
$\lim_{x \rightarrow 0^+}$	1	1			
1	2	1	0	incr.	linear
$\lim_{x \rightarrow \infty}$	∞	1			



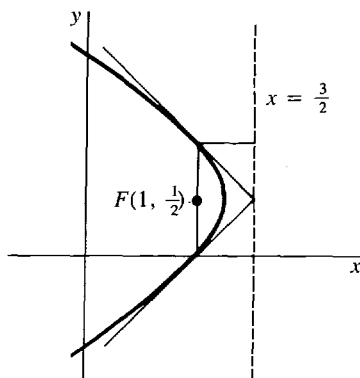
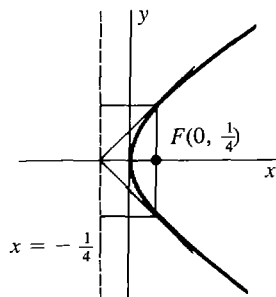
55	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	$-\infty$	1			
	-1	$-\sqrt{2}$	$1/\sqrt{2}$	$-$	incr.	$\cap$
	$\lim_{x \rightarrow 0^-}$	-1	0		jump	
	$\lim_{x \rightarrow 0^+}$	1	0			
	1	$\sqrt{2}$	$1/\sqrt{2}$	$+$	incr.	$\cup$
	$\lim_{x \rightarrow \infty}$	∞	1			



Section 5.4

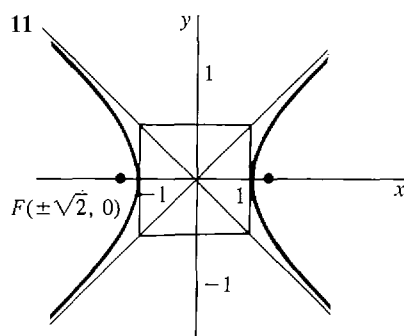
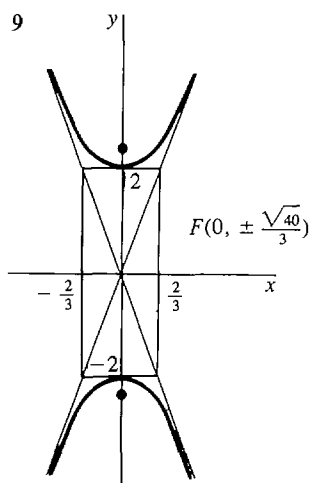
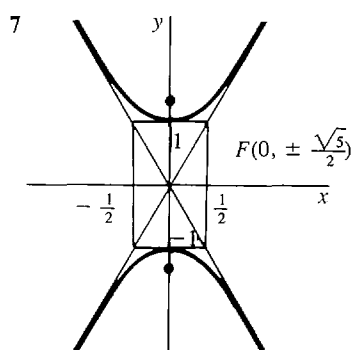
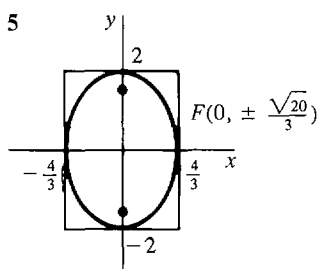
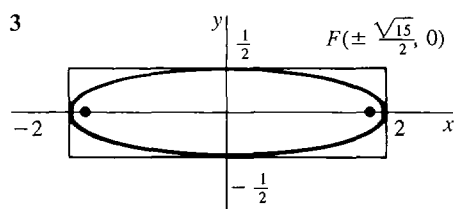
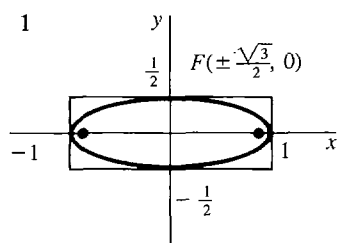


15 focus $(1/4, 0)$, directrix $x = -1/4$ 17 focus $(3/2, 1/2)$, directrix $x = 2$



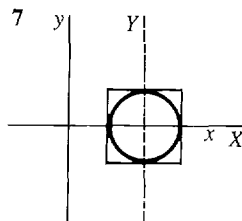
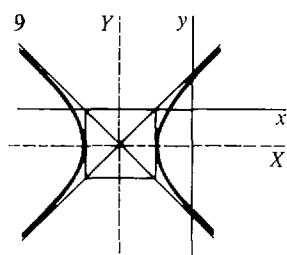
19 $y = (1/4)x^2 - x + 2$ 21 $(1, 3)$

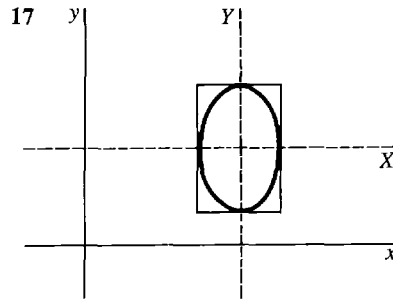
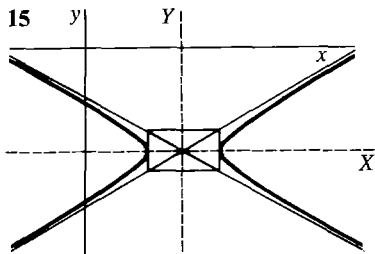
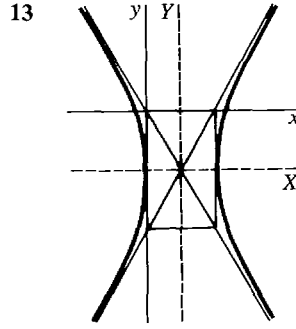
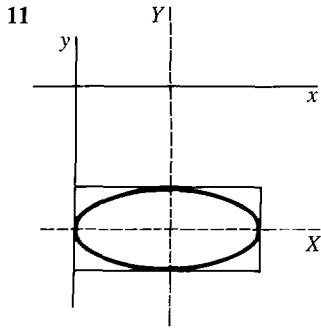
Section 5.5



Section 5.6

1 hyperbola 3 parabola 5 ellipse





Section 5.7

- 1 $\alpha = 45^\circ, X^2 - Y^2 + 8 = 0$ 3 $\alpha = 45^\circ, -2X^2 + 6Y^2 = 1$
 5 $\alpha = 30^\circ, 2X^2 - 2Y^2 = 7$ 7 $\alpha = 22.5^\circ, 1.207X^2 - 0.207Y^2 = 3$
 9 $\alpha = -15^\circ, 4.232X^2 + 0.768Y^2 = 5$

Section 5.8

Any smaller value of $\delta > 0$ or larger value of B is also correct.

- 1 $\delta = 10^{-3}$ 3 $\delta = 2 - (0.51)^{-1} \sim 0.039$ 5 $\delta = 10^{-4}$
 7 $\delta = 1 - \sqrt{1 - 10^{-6}} \sim 5 \times 10^{-7}$ 9 $\delta = 10^{-2}$ 11 $\delta = 10^{-3}$ 13 $\delta = 10^{-4}$
 15 $\delta = 1 - \sqrt{0.99} \sim 5 \times 10^{-3}$ 17 $B = 99/4 = 24.75$ 19 $B = \frac{5 + \sqrt{8025}}{4} \sim 23.7$
 21 $B = \frac{10^4 - 1}{5} \sim 2 \times 10^3$
 23 For all $\varepsilon > 0$ there exists $\delta > 0$ such that whenever $c - \delta < x < c$, $|f(x) - L| < \varepsilon$.
 25 For all $A > 0$ there exists $B > 0$ such that whenever $x > B$, $f(x) < -A$.

Section 5.9

- 1 1.42332 3 0.63688 5 1.22074 7 2.93923 9 0.38197 11 0.56714
 13 1.10606 15 1.30633

Section 5.10

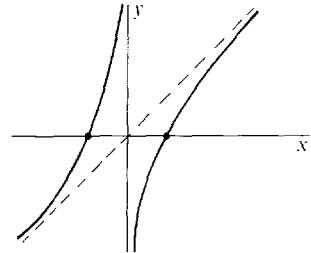
- 1 $f'(1) = 2$, error $\leq \Delta x$ 3 $f'(4) = -(1/8)$, error $\leq (3/128)\Delta x$
 5 $f'(3) = -1/9$, error $\leq (1/27)\Delta x$ 7 $f'(0) = 1$, error $\leq 0.5\Delta x$
 9 $f'(\pi/3) = -\sqrt{3}$, error $\leq 2\Delta x$ 11 $f'(1) = 1$, error $\leq \Delta x/2$

- 13 $f'(1) = e$, error $\leq (1/2)e \Delta x$
 15 $f'(100) = 1/20$, error $\leq (1/8) \cdot 99^{-3/2} \Delta x$ or $0.000127 \Delta x$
 17 $f'(2) = (2/\sqrt{5})$, error $\leq 1/(4\sqrt{2}) \Delta x$ 19 $f'(1) = \sqrt{2} + 2^{-3/2}$, error $\leq \Delta x/2$
 21 $\sqrt[3]{65} \sim 8\frac{1}{16}$, error $\leq 1/4096$ 23 $(0.301)^4$ or 0.008208 , error $\leq 6 \times 10^{-7}$
 25 $1/97$ or $10^{-2} + 3 \times 10^{-4} = 0.0103$, error $\leq 10^{-5}$
 27 $\sqrt[3]{1.02} + \sqrt[3]{1.02} \sim 2\frac{1}{60}$, error $\leq \frac{17}{8} \times 10^{-4}$ 29 $(1.003)^5$ or 1.015 , error $\leq 10^{-4}$
 31 $\sin(\pi/3 + 0.004)$ or $\sqrt{3}/2 + 0.002$, error $\leq 8 \times 10^{-6}$
 33 $\tan(0.005)$ or 0.005 , error $\leq 10^{-6}$ 35 $e^{0.002}$ or 1.002 , error $\leq 3 \times 10^{-6}$
 37 $\ln(1.006)$ or 0.006 , error $\leq 18 \times 10^{-6}$

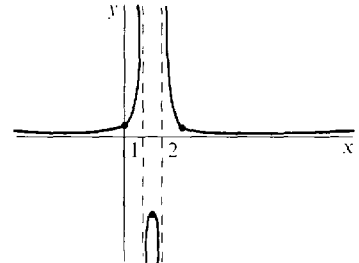
Extra Problems for Chapter 5

1 0 3 0 5 ∞ 7 0 9 3/2

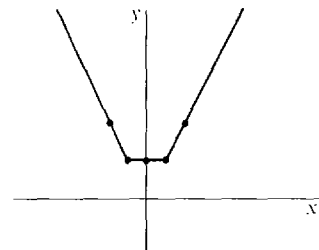
11	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	$-\infty$	1			
	-1	0	2	+	incr.	$\cup$
	$\lim_{x \rightarrow 0^-}$	∞	∞			
	$\lim_{x \rightarrow 0^+}$	$-\infty$	∞			
	1	0	2	-	incr.	$\cap$
	$\lim_{x \rightarrow \infty}$	∞	1			

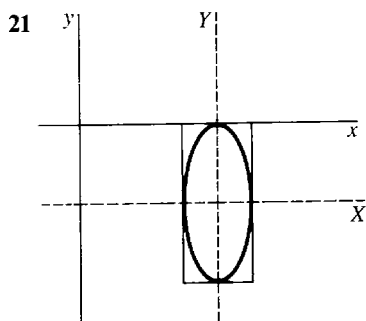
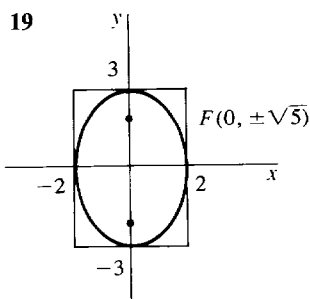
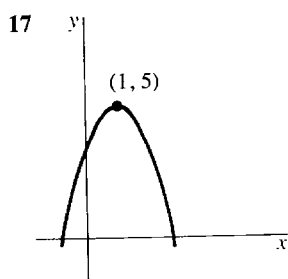


13	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	0	0			
	0	$\frac{1}{2}$	$\frac{3}{4}$	+	incr.	$\cup$
	$\lim_{x \rightarrow 1^-}$	∞	∞			
	$\lim_{x \rightarrow 1^+}$	$-\infty$	∞			
	$\frac{3}{2}$	-4	0	-	max.	$\cap$
	$\lim_{x \rightarrow 2^-}$	$-\infty$	$-\infty$			
	$\lim_{x \rightarrow 2^+}$	∞	$-\infty$			
	3	$\frac{1}{2}$	$-\frac{3}{4}$	+	decr.	$\cup$
	$\lim_{x \rightarrow \infty}$	0	0			



15	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow -\infty}$	∞	-2			
	-2	4	-2	0	decr.	linear
	$\lim_{x \rightarrow -1^-}$	2	-2		corner	
	$\lim_{x \rightarrow -1^+}$	2	0			
	0	2	0	0	constant	linear
	$\lim_{x \rightarrow 1^-}$	2	0		corner	
	$\lim_{x \rightarrow 1^+}$	2	2			
	2	4	2	0	incr.	linear
	$\lim_{x \rightarrow \infty}$	∞	2			





- 23 $\alpha = 45^\circ$, $X^2 - Y^2 = 18$ 25 $\delta \leq 0.155$ 27 1.7866 29 $(3/4096) \Delta x$
 31 $25 - 2/15 = 24.8666$, error $\leq 1/(9 \cdot (124)^{4/3})$

Section 6.1

- 1 $1/3$ 3 $\sqrt{3}/12$ 5 $\pi/24$ 7 $2cr^2/3$

Section 6.2

- 1 (a) $\pi/5$ (b) $\pi/2$ 3 (a) 8π (b) $128\pi/5$ 5 (a) $\pi/3$ (b) $\pi/3$
 7 (a) $4\pi/3$ (b) $(2/3)\pi(2\sqrt{2} - 1)$ 9 (a) $31\pi/160$ (b) π 11 (a) $4\pi/45$ (b) $\pi/3$
 13 (a) 27π (b) 18π 15 (a) $2\pi/35$ (b) $\pi/10$ 17 (a) $\pi/3$ (b) $\pi/9$
 19 $20\pi/3$ (b) $29\pi/6$ 21 (a) $16\pi/3$ (b) $184\pi/15$ 23 2π 25 $(\pi^2/4) - (\pi/2)$
 27 $(\pi/2)(e^2 - 1)$ 29 $(\pi/6)(e^2 - 1)$ 31 $\pi \ln 2$ 33 $\pi(3 - \ln 4)$ 35 2π
 37 2π 39 $\pi(e - 1)$ 41 $2\pi(e^{-1} - e^{-4})$ 43 $2\pi \ln 2$ 45 $(\pi/2) \ln 7$
 47 $\frac{4}{3}\pi(r^2 - a^2)^{3/2}$ 49 $\frac{1}{3}\pi r^2 h - \pi a^2 h + \frac{2\pi h a^3}{3r}$
 51 (a) $\pi\left(\frac{b^2 a}{3} + \frac{2}{3}r^3 - r^2 a + \frac{a^3}{3}\right)$ or $\frac{2}{3}\pi r^2(r - a)$
 (b) $\frac{2}{3}\pi(ba^2 + b^3)$ or $\frac{2}{3}\pi[a^2\sqrt{r^2 - a^2} + (r^2 - a^2)^{3/2}]$ 53 $2\pi^2 cr^2$

Section 6.3

- 1 $\frac{2}{3}(6\sqrt{6} - 3\sqrt{3})$ 3 $\frac{8}{3}(3\sqrt{3}/2\sqrt{2} - 1)$ 5 $\frac{8}{27}(10\sqrt{10} - 1)$ 7 $379/12$
 9 $387/20$ 11 $3/2$ 13 36 15 $\frac{4}{3}(2^{5/2} - 1)$ 17 $3\sqrt{3}/2$
 19 $8 \cdot 10\sqrt{10} - 37\sqrt{37}$ 21 2π 23 $4\sqrt{2}$ 25 $\frac{t^2}{\sqrt{1 + 4t^2}}$
 27 $\int_0^4 \sqrt{1 + (4x - 1)^2} dx$ 29 $\int_1^2 \sqrt{4 + \frac{1}{4t}} dt$

$$31 \quad \int_1^2 \sqrt{1 + \frac{1}{4x}} dx \sim \frac{1}{4} \left(\frac{\sqrt{5}}{4} + \sqrt{\frac{3}{2}} + \sqrt{\frac{7}{4}} + \sqrt{2} + \frac{3}{4} \right) \sim 1.32$$

$$33 \quad \int_1^5 \sqrt{1 + x^{-4}} dx \sim \frac{\sqrt{2}}{2} + \frac{\sqrt{17}}{4} + \frac{\sqrt{82}}{9} + \frac{\sqrt{257}}{16} + \frac{\sqrt{626}}{50} \sim 4.246$$

Section 6.4

$$1 \quad \frac{\pi}{6} (17\sqrt{17} - 1) \quad 3 \quad \frac{2\pi}{81} \left(\frac{2}{5} \cdot 10^{5/2} - \frac{2}{3} \cdot 10^{3/2} + \frac{4}{15} \right) \sim 8.2 \quad 5 \quad 256\pi/15$$

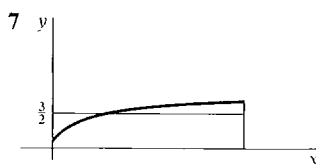
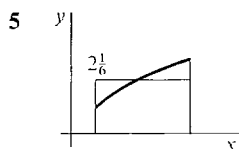
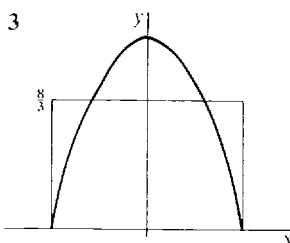
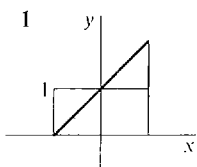
$$7 \quad 1575\pi/8 \quad 9 \quad \frac{2\pi}{3} (10\sqrt{10} - 2\sqrt{2}) \quad 11 \quad \pi(2\sqrt{2} - 1) \quad 13 \quad \frac{\pi}{9} (2\sqrt{2} - 1)$$

$$15 \quad 47\pi/16 \quad 17 \quad 7\pi/9 \quad 19 \quad 16\pi\sqrt{5} \quad 21 \quad 2\pi ra \quad 23 \quad (a) \int_0^1 2\pi x \sqrt{1 + 25x^8} dx$$

$$(b) \int_0^1 2\pi x^5 \sqrt{1 + 25x^8} dx \quad 25 \quad (a) \int_1^{10} 2\pi(t^2 + t)\sqrt{8t^2 + 4t + 1} dt$$

$$(b) \int_1^{10} 2\pi(t^2 - 1)\sqrt{8t^2 + 4t + 1} dt \quad 27 \quad \int_0^1 \pi x^2 \sqrt{1 + x^2} dx \sim 1.357$$

Section 6.5



$$9 \quad 3 - (2/\sqrt{3}) \quad 11 \quad -6 \quad 13 \quad 0 \quad 15 \quad 2/\pi \quad 17 \quad 1/\pi \quad 19 \quad (1/2)(e - e^{-1})$$

$$21 \quad (1/3) \ln 4 \quad 23 \quad 1 \quad 25 \quad 8/9 \quad 27 \quad 6\sqrt{15}/25 \quad 29 \quad 13/2 \quad 31 \quad 116/45$$

$$33 \quad (a) 2 \quad (b) 32/7$$

Section 6.6

$$1 \quad (a) 4 \quad (b) M_x = 0, M_y = 4 \quad (c) (1, 0) \quad 3 \quad (a) 128/3 \quad (b) M_x = 512/5, M_y = 0$$

$$(c) (0, 12/5) \quad 5 \quad (a) 6k \quad (b) M_x = 8k, M_y = 2k \quad (c) (\frac{1}{3}, \frac{4}{3}) \quad 7 \quad (a) 128/15$$

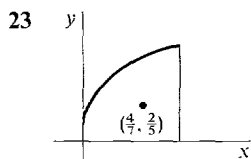
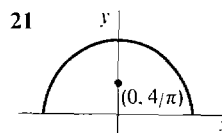
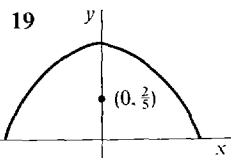
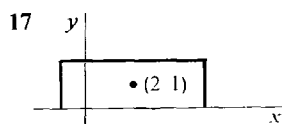
$$(b) M_x = 1024/105, M_y = 0 \quad (c) (0, \frac{8}{9}) \quad 9 \quad (a) \frac{1}{2} \quad (b) M_x = \frac{1}{8}, M_y = \frac{1}{3} \quad (c) (\frac{2}{3}, \frac{1}{4})$$

$$11 \quad (a) 2\sqrt{2} - 2 \quad (b) M_x = 1 - \frac{\sqrt{2}}{2}, M_y = \frac{4\sqrt{2} - 2}{3}$$

$$(c) \left(\frac{2\sqrt{2} - 1}{3\sqrt{2} - 3}, \frac{2 - \sqrt{2}}{4\sqrt{2} - 4} \right) \text{ or } \left(1 + \frac{\sqrt{2}}{3}, \frac{\sqrt{2}}{4} \right)$$

$$13 \quad (a) 4/3 \quad (b) M_x = 1/2, M_y = 0 \quad (c) (0, 3/8)$$

$$15 \quad (a) 128/3 \quad (b) M_x = 1024/15, M_y = 512/5 \quad (c) (\frac{12}{5}, \frac{8}{5})$$



- 25 $2/3$ 27 $e^2 - 1$ 29 $(2 \ln 2, 7/24)$ 31 $(8/15, 16/105)$ 33 $(1/2, 2/5)$
 35 80 ft lbs 37 $320/3$ ft lbs 39 50 ft lbs 41 215 ft lbs 43 $9k/400$

Section 6.7

- 1 $1/2$ 3 diverges to ∞ 5 diverges to $-\infty$ 7 diverges to ∞ 9 $1/2$
 11 diverges to ∞ 13 3 15 6 17 $-3/2$ 19 3 21 diverges to ∞
 23 diverges to ∞ 25 diverges 27 $1/2$ 29 diverges 31 $4\sqrt{2}$ 33 ∞
 37 4 39 $2/3$ 43 (a) π (b) ∞ 45 (a) ∞ (b) 8π 47 $4/3$
 49 (a) $11\pi/9$ (b) $16\pi/15$ 51 (a) $\frac{\pi}{6}(5\sqrt{5} - 1)$ (b) $\int_0^1 2\pi x \sqrt{1 + \frac{1}{4x}} dx$
 53 (a) $2\pi r a$ (b) $2\pi r^2 - 2\pi r \sqrt{r^2 - a^2}$

Extra Problems for Chapter 6

- 1 $8r^3/3$ 3 $2r^3/3$ 5 (a) $11\pi/3$ (b) $(16\pi/3) - 2\pi\sqrt{3}$ 7 (a) 16π (b) $16\pi/3$
 9 $\pi p/(p+1)$ 11 $\frac{1}{27}(46\sqrt{46} - 10\sqrt{10})$ 13 5 15 $(b-a)\sqrt{A^2 + C^2}$
 17 $\frac{\pi}{3A}[(8A^2 + 4AB + B^2)^{3/2} - (4A^2 + B^2)^{3/2}]$ 19 $\frac{b^{p+1} - 1}{(b-1)(p+1)}$ 21 $(p+1)^{-1/p}$
 23 $(\frac{1}{2}, \frac{2}{3})$ 25 $(\frac{5}{2}, 0)$ 27 15 ft lbs 29 diverges to ∞ 31 $-5/4$
 33 diverges to ∞ 35 8 37 $a^2 h/3$ 39 $m = \pi\rho, M_x = 2\rho, M_y = 0, (\bar{x}, \bar{y}) = (0, 2/\pi)$
 43 $\pi\rho r^4/4$ 45 $\pi\rho b^2/2$

Section 7.1

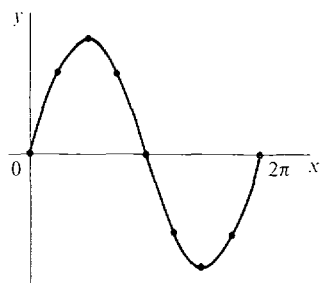
- 7 $(\pi/4) + k\pi$ 9 none 13 0 15 0 17 0 19 $k\pi$

Section 7.2

- 1 $5 \cos(5x)$ 3 $6\theta \cos(3\theta^2)$ 5 $4 \sec^2(4\theta - 3)$ 7 $a \cos \theta - b \sin \theta$
 9 $-\frac{1}{2\sqrt{x}} \sin(\sqrt{x})$ 11 $\cos \theta \sec^2(\sin \theta)$ 13 $\frac{3 \csc(3t) \cot(3t)}{(2 + \csc(3t))^2}$ 15 $\frac{1}{2 \sin y \cos y}$
 17 $3/2$ 19 ∞ 21 2 23 1

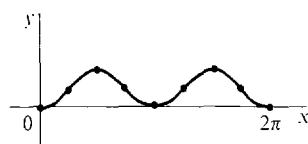
25

x	$f(x)$	$f'(x)$	$f''(x)$		
0	0	3	0	incr.	infl.
$\pi/4$	$3/\sqrt{2}$	$3/\sqrt{2}$	—	incr.	$\cap$
$\pi/2$	3	0	—	max.	$\cap$
$3\pi/4$	$3/\sqrt{2}$	$-3/\sqrt{2}$	—	decr.	$\cap$
π	0	-3	0	decr.	infl.
$5\pi/4$	$-3/\sqrt{2}$	$-3/\sqrt{2}$	+	decr.	$\cup$
$3\pi/2$	-3	0	+	min.	$\cup$
$7\pi/4$	$-3/\sqrt{2}$	$3/\sqrt{2}$	+	incr.	$\cup$
2π	0	3	0	incr.	infl.



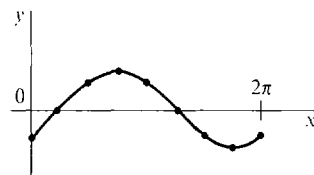
27

x	$f(x)$	$f'(x)$	$f''(x)$		
0	0	0	+	min.	$\cup$
$\pi/4$	1/2	1	0	incr.	infl.
$\pi/2$	1	0	—	max.	$\cap$
$3\pi/4$	1/2	-1	0	decr.	infl.
π	0	0	+	min.	$\cup$
$5\pi/4$	1/2	1	0	incr.	infl.
$3\pi/2$	1	0	—	max.	$\cap$
$7\pi/4$	1/2	-1	0	decr.	infl.
2π	0	0	+	min.	$\cup$



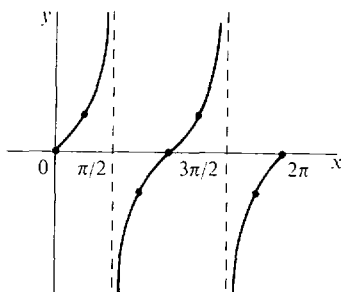
29

x	$f(x)$	$f'(x)$	$f''(x)$		
0	$-1/\sqrt{2}$	$1/\sqrt{2}$	+	incr.	$\cup$
$\pi/4$	0	1	0	incr.	infl.
$\pi/2$	$1/\sqrt{2}$	$1/\sqrt{2}$	—	incr.	$\cap$
$3\pi/4$	1	0	—	max.	$\cap$
π	$1/\sqrt{2}$	$-1/\sqrt{2}$	—	decr.	$\cap$
$5\pi/4$	0	-1	0	decr.	infl.
$3\pi/2$	$-1/\sqrt{2}$	$-1/\sqrt{2}$	+	decr.	$\cup$
$7\pi/4$	-1	0	+	min.	$\cup$
2π	$-1/\sqrt{2}$	$1/\sqrt{2}$	+	incr.	$\cup$

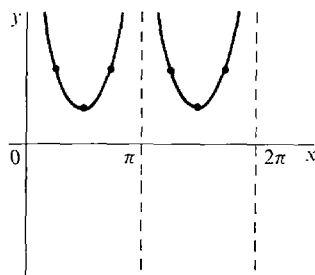


31

x	$f(x)$	$f'(x)$	$f''(x)$		
0	0	1	0	incr.	infl.
$\pi/4$	1	2	+	incr.	$\cup$
$\lim_{x \rightarrow \pi/2^-}$	∞	∞			
$\lim_{x \rightarrow \pi/2^+}$	$-\infty$	∞			
$3\pi/4$	-1	2	—	incr.	$\cap$
π	0	1	0	incr.	infl.
$5\pi/4$	1	2	+	incr.	$\cup$
$\lim_{x \rightarrow 3\pi/2^-}$	∞	∞			
$\lim_{x \rightarrow 3\pi/2^+}$	$-\infty$	∞			
$7\pi/4$	-1	2	—	incr.	$\cap$
2π	0	1	0	incr.	infl.



33	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow 0^+}$	∞	$-\infty$			
	$\pi/4$	2	-4	+	decr.	$\cup$
	$\pi/2$	1	0	+	min.	$\cup$
	$3\pi/4$	2	4	+	incr.	$\cup$
	$\lim_{x \rightarrow \pi^-}$	∞	∞			
	$\lim_{x \rightarrow \pi^+}$	∞	$-\infty$			
	$5\pi/4$	2	-4	+	decr.	$\cup$
	$3\pi/2$	1	0	+	min.	$\cup$
	$7\pi/4$	2	4	+	incr.	$\cup$
	$\lim_{x \rightarrow 2\pi^-}$	∞	∞			



- 37 $-\frac{1}{2}\cos(2t) + C$ 39 $\frac{1}{3}\sec^3 x + C$ 41 $2\sin(\sqrt{x}) + C$ 43 $-\frac{1}{5}\csc(5\theta) + C$
 45 $2\sqrt{\sec x + 1} + C$ 47 $\tan \theta - \sec \theta + C$ 49 2 51 $(3 - \sqrt{3})/2$ 53 ∞
 55 $-\frac{3}{10}$ radians/sec 57 6 59 $1/2$ 61 2π 63 $\sqrt{2}$ 65 $\pi\sqrt{2}$

Section 7.3

- 1 $\pi/3$ 3 $-\pi/4$ 5 $\pi/3$ 7 $\sqrt{1-x^2}$ 9 $\frac{\pi}{2} - x$
 15 $\frac{5}{|5x-2|\sqrt{(5x-2)^2-1}}$ 17 $\frac{2x}{\sqrt{1-x^4}}$ 19 $\arcsin t + \frac{t}{\sqrt{1-t^2}}$ 21 $\frac{1-x}{\sqrt{1-x^2}}$
 23 $\arcsin x$ 25 $-\frac{1}{2\sqrt{x}(x+1)}$ 27 $-\pi/2$ 29 1 31 $\frac{1}{3}\arctan(x/3) + C$
 33 $\arcsin(2x-1) + C$ 35 $\operatorname{arcsec}(2x) + C$ 37 $\frac{1}{2}\arcsin(x^2) + C$
 39 $2\operatorname{arcsec}(\sqrt{x}) + C$ or $2\arctan(\sqrt{x-1}) + C$ 41 $\frac{1}{2}(\arcsin x)^2 + C$ 43 $\pi/3$
 45 $\pi/6$ 47 π/a 49 $\pi/2$

Section 7.4

- 1 $x \sin x + \cos x + C$ 3 $t^2 \sin t + 2t \cos t - 2 \sin t + C$
 5 $-\frac{1}{2}t \cos(2t-1) + \frac{1}{4} \sin(2t-1) + C$
 7 $-\frac{x^2}{4} \cos(4x) + \frac{x}{8} \sin(4x) + \frac{1}{32} \cos(4x) + C$
 9 $\frac{1}{4}x^4 \operatorname{arcsec} x - \frac{1}{12}(x^2-1)^{3/2} - \frac{1}{4}\sqrt{x^2-1} + C$
 11 $-2\sqrt{x} \cos(\sqrt{x}) + 2 \sin(\sqrt{x}) + C$ 13 $(x+1) \arctan(\sqrt{x}) - \sqrt{x} + C$
 15 $x^2\sqrt{x^2-1} - \frac{2}{3}(x^2-1)^{3/2} + C$ or $\frac{1}{3}(x^2-1)^{3/2} + \sqrt{x^2-1} + C$ or $(\frac{1}{3}x^2 + \frac{2}{3})\sqrt{x^2-1} + C$
 17 $-\frac{1}{4}x \cos(2x) + \frac{1}{8} \sin(2x) + C$ or $\frac{1}{2}x \sin^2 x - \frac{1}{4}x + \frac{1}{4} \sin x \cos x + C$
 19 $\frac{2}{3} \sin^3 \theta + C$ or $\frac{1}{3}[\cos \theta \sin(2\theta) - 2 \sin \theta (\cos(2\theta))] + C$
 21 $\frac{1}{8} \cos(4x) - \frac{1}{12} \cos(6x) + C$ or $\frac{5}{24} \sin x \sin(5x) + \frac{1}{24} \cos x \cos(5x) + C$
 23 $\frac{1}{2} \sin(t^2) - \frac{1}{2}t^2 \cos(t^2) + C$ 25 $\frac{1}{x} \cos\left(\frac{1}{x}\right) - \sin\left(\frac{1}{x}\right) + C$
 27 $(t^2+4)^{3/2} \left(\frac{t^2}{5} - \frac{8}{15}\right) + C$ or $\frac{1}{3}t^2(t^2+4)^{3/2} - \frac{2}{15}(t^2+4)^{5/2} + C$ or $-\frac{4}{3}(t^2+4)^{3/2} + \frac{1}{5}(t^2+4)^{5/2} + C$ 29 $(\pi/2) - 1$ 31 $\pi/2$ 33 $1/2$
 35 $\frac{2}{3}\pi - \frac{\sqrt{3}}{2}$

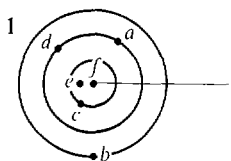
Section 7.5

- 1 $(1/\cos t) + \cos t + C$ 3 $-\cot x - x + C$ 5 $\frac{1}{4} \cos^3 x \sin x + \frac{3}{8} \sin x \cos x + \frac{3}{8} x + C$
 or $\frac{3}{8} x + \frac{1}{4} \sin(2x) + \frac{1}{32} \sin(4x) + C$ 7 $\frac{1}{6} \tan^6 x + \frac{1}{4} \tan^4 x + C$ or
 $\frac{1}{6} \sec^6 x - \frac{1}{4} \sec^4 x + C$ 9 $\frac{1}{3} \sin^3 x - \frac{1}{5} \sin^5 x + C$ 11 $-\frac{1}{3} \cot^3 \theta + C$
 13 $\frac{2}{9} (\tan x)^{9/2} + \frac{2}{5} (\tan x)^{5/2} + C$ 15 $\tan \theta - \cot \theta + C$ or $-2 \cot(2\theta) + C$
 17 $-\cot \theta + \csc \theta + C$ 19 $4/3$ 21 $\frac{\pi}{4} - \frac{2}{3}$ 23 $3\pi/8$
 25 $\cos(\sqrt{x}) \sin(\sqrt{x}) + \sqrt{x} + C$ or $\frac{1}{2} \sin(2\sqrt{x}) + \sqrt{x} + C$
 27 $-x \cos x + \frac{1}{3} x \cos^3 x + \frac{2}{3} \sin x + \frac{1}{9} \sin^3 x + C$
 29 $\frac{1}{3} x \sin^3 x + \frac{1}{3} \cos x - \frac{1}{9} \cos^3 x + C$ 31 $\frac{1}{9} \tan^9 \theta + \frac{2}{7} \tan^7 \theta + \frac{1}{5} \tan^5 \theta + C$
 33 $\frac{1}{2} \sec x \tan x + \frac{1}{2} \int \sec x dx$ 35 $\frac{1}{2} \sec x \tan x - \frac{1}{2} \int \sec x dx$
 37 $-\frac{1}{4} \csc^4 x \cos x + \frac{1}{8} \csc^2 x \cos x - \frac{1}{8} \int \csc x dx$ 39 $\int \sec x dx + \int \csc x dx$
 41 $\int x^n \sin x dx = -x^n \cos x + n \int x^{n-1} \cos x dx = -x^n \cos x + nx^{n-1} \sin x - n(n-1) \int x^{n-2} \sin x dx$
 43 (a) $\pi^2/16$ (b) $\pi^2/4$

Section 7.6

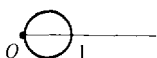
- 1 $\frac{1}{2} \arcsin(2x) + C$ 3 $\frac{1}{3}(9+x^2)^{3/2} - 9(9+x^2)^{1/2} + C$ or $\sqrt{9+x^2}(\frac{1}{3}x^2 - 6) + C$
 5 $\frac{x}{4\sqrt{4-x^2}} + C$ 7 $\arccos\left(\frac{\cos \theta}{\sqrt{2}}\right) + C$ or $-\arcsin\left(\frac{\cos \theta}{\sqrt{2}}\right) + C$
 9 $-\frac{1}{x} - \arctan x + C$ 11 $2 \arcsin(x/2) - \frac{1}{2}x\sqrt{4-x^2} + C$
 13 $\frac{1}{8} \arcsin x - \frac{1}{4}x(1-x^2)^{3/2} + \frac{1}{8}x\sqrt{1-x^2} + C$
 15 $2 \arcsin\left(\frac{x-2}{2}\right) + \frac{1}{2}(x-2)\sqrt{4x-x^2} + C$ 17 $\frac{1}{48}(4x^2-1)^{3/2} + \frac{1}{16}\sqrt{4x^2-1} + C$
 or $\sqrt{4x^2-1}\left(\frac{1}{24} - \frac{1}{12}x^2\right) + C$ 19 $\frac{1}{3}(a^2-x^2)^{3/2} - a^2\sqrt{a^2-x^2} + C$
 or $-\frac{1}{3}\sqrt{a^2-x^2}(2a^2+x^2) + C$ 21 $\frac{1}{2}\sqrt{x^4-1} - \frac{1}{2} \arccsc(x^2) + C$
 23 $\sqrt{a^2+x^2} + \frac{a^2}{\sqrt{a^2+x^2}} + C$ 25 $\pi/2$ 27 $1/9$ 29 ∞
 31 $(\frac{1}{2}x^2 - \frac{1}{4}) \arcsin x + \frac{1}{4}x\sqrt{1-x^2} + C$ 33 $\frac{1}{3}x^3 \arcsin x + \frac{1}{3}\sqrt{1-x^2} - \frac{1}{9}(1-x^2)^{3/2} + C$
 35 $-\frac{\arcsin x}{2x^2} - \frac{\sqrt{1-x^2}}{2x} + C$ 37 $\frac{2\pi^2}{3\sqrt{3}} + \frac{\pi}{2}$

Section 7.7

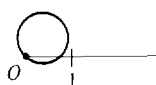


- 3 $r = \frac{2}{\sin \theta - 5 \cos \theta}$ 5 $r = 2 \sec \theta$ 7 $r \sin \theta = r^2 \cos^2 \theta + 1$
 9 $r \sin \theta = 3r^2 \cos^2 \theta - 2r \cos \theta$ or $r = \frac{\sin \theta + 2 \cos \theta}{3 \cos^2 \theta}$ 11 $r = \sin \theta$

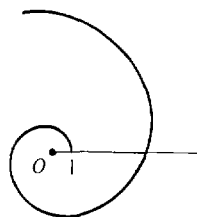
13



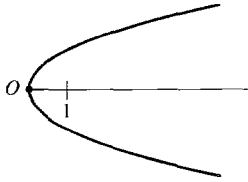
15



17



19

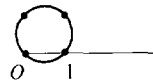


21 $x = \sin(3\theta) \cos \theta$, $y = \sin(3\theta) \sin \theta$ 23 $x = \theta^2 \cos \theta$, $y = \theta^2 \sin \theta$

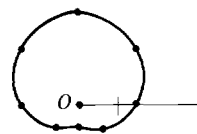
Section 7.8

1 θ 3 $-\cot \theta$ 5 $-\frac{1 + \cot \theta}{\sin \theta}$

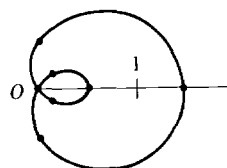
7	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	0	1	1	1	incr.
	$\pi/4$	$\sqrt{2}$	0		max.
	$\pi/2$	1	-1	-1	decr.
	$3\pi/4$	0	$-\sqrt{2}$		crosses O
	π	-1	-1	1	incr.
	$5\pi/4$	$-\sqrt{2}$	0		max.
	$3\pi/2$	-1	1	-1	decr.
	$7\pi/4$	0	$\sqrt{2}$		crosses O
	2π	1	1	1	incr.



9	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	0	1.5	1	1.5	incr.
	$\pi/4$	2.2	0.7	3.1	incr.
	$\pi/2$	2.5	0		max.
	$3\pi/4$	2.2	-0.7	-3.1	decr.
	π	1.5	-1	-1.5	decr.
	$5\pi/4$	0.8	-0.7	-1.1	decr.
	$3\pi/2$	0.5	0		min.
	$7\pi/4$	0.8	0.7	1.1	incr.
	2π	1.5	1	1.5	incr.

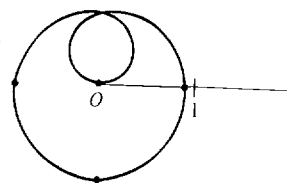


11	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	0	1.5	0		max.
	$\pi/2$	0.5	-1	-0.5	decr.
	$2\pi/3$	0	-0.9		crosses O
	$3\pi/4$	-0.2	-0.7	0.3	incr.
	π	-0.5	0		max.
	$5\pi/4$	-0.2	0.7	-0.3	decr.
	$4\pi/3$	0	0.9		crosses O
	$3\pi/2$	0.5	1	0.5	incr.
	2π	1.5	0		max.



13

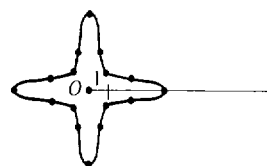
θ	r	$dr/d\theta$	$\tan \psi$	$ r $
0	0	$\frac{1}{3}$		crosses O
π	0.9	$\frac{1}{6}$	5	incr.
1.5π	1	0		max.
2π	0.9	$-\frac{1}{6}$	-5	decr.
3π	0	$-\frac{1}{3}$		crosses O
4π	-0.9	$-\frac{1}{6}$	5	incr.
4.5π	-1	0		max.
5π	-0.9	$\frac{1}{6}$	-5	decr.
6π	0	$\frac{1}{3}$		crosses O



15

θ	r	$dr/d\theta$	$\tan \psi$	$ r $
0	4	0		max.
$\pi/8$	2.5	-6	-0.4	decr.
$2\pi/8$	1	0		min.
$3\pi/8$	2.5	6	0.4	incr.
$4\pi/8$	4	0		max.
$5\pi/8$	2.5	-6	-0.4	decr.
$6\pi/8$	1	0		min.
$7\pi/8$	2.5	6	0.4	incr.
π	4	0		max.

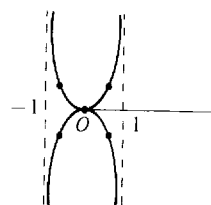
repeats



17

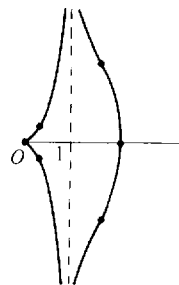
θ	r	$dr/d\theta$	$\tan \psi$	$ r $
0	0	1		crosses O
$\pi/4$	1	2	$\frac{1}{2}$	incr.
$\lim_{\theta \rightarrow \pi/2^-}$	∞			$x \rightarrow 1$
$\lim_{\theta \rightarrow \pi/2^+}$	$-\infty$			$x \rightarrow 1$
$3\pi/4$	-1	2	$-\frac{1}{2}$	decr.
π	0	1		crosses O

repeats, with $x \rightarrow -1$ as $\theta \rightarrow 3\pi/2$

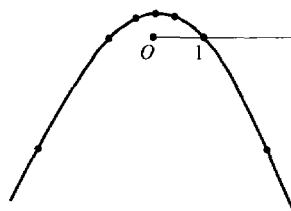


19

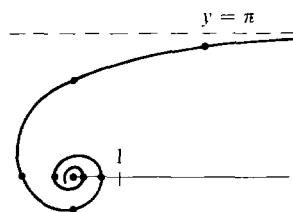
θ	r	$dr/d\theta$	$\tan \psi$	$ r $
0	2	0		min.
$\pi/4$	2.4	2.4	1	incr.
$\lim_{\theta \rightarrow \pi/2^-}$	∞			$x \rightarrow 1$
$\lim_{\theta \rightarrow \pi/2^+}$	$-\infty$			$x \rightarrow 1$
$3\pi/4$	-0.4	0.4	-1	decr.
π	0	0		cusp at O
$5\pi/4$	-0.4	-0.4	1	incr.
$\lim_{\theta \rightarrow 3\pi/2^-}$	$-\infty$			$x \rightarrow 1$
$\lim_{\theta \rightarrow 3\pi/2^+}$	∞			$x \rightarrow 1$
$7\pi/4$	2.4	-2.4	-1	decr.
2π	2	0		min.



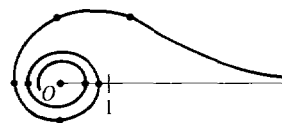
21	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	0	1	-1	-1	decr.
	$\pi/4$	0.6	-0.3	-2	decr.
	$\pi/2$	0.5	0		min.
	$3\pi/4$	0.6	0.3	2	incr.
	π	1	1	1	incr.
	$5\pi/4$	3.4	8	0.4	incr.
	$\lim_{\theta \rightarrow 3\pi/2^-}$	∞			$x \rightarrow -\infty$
	$\lim_{\theta \rightarrow 3\pi/2^+}$	∞			$x \rightarrow \infty$
	$7\pi/4$	3.4	-8	-0.4	decr.
	2π	1	-1	-1	decr.



23	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	$\lim_{\theta \rightarrow 0^+}$	∞			$y \rightarrow \pi$
	$\pi/4$	4	$-16/\pi$	$-\pi/4$	decr.
	$\pi/2$	2	$-4/\pi$	$-\pi/2$	decr.
	π	1	$-1/\pi$	$-\pi$	decr.
	$3\pi/2$	$\frac{2}{3}$	$-\frac{4}{3}\pi$	$-3\pi/2$	decr.
	2π	$\frac{1}{2}$	$-\frac{1}{4}\pi$	-2π	decr.
	3π	$\frac{1}{3}$	$-\frac{1}{6}\pi$	-3π	decr.
	4π	$\frac{1}{4}$	$-\frac{1}{16}\pi$	-4π	decr.



25	θ	r	$dr/d\theta$	$\tan \psi$	$ r $
	$\lim_{\theta \rightarrow 0^+}$	∞			$y \rightarrow O$
	$\pi/4$	2	$-4/\pi$	$-\pi/2$	decr.
	$\pi/2$	$\sqrt{2}$	$-\sqrt{2}/\pi$	$-\pi$	decr.
	π	1	$-\frac{1}{2}\pi$	-2π	decr.
	$3\pi/2$	$\sqrt{\frac{1}{3}}$	-	-	decr.
	2π	$1/\sqrt{2}$	-	-	decr.
	3π	$1/\sqrt{3}$	-	-	decr.
	4π	$\frac{1}{2}$	-	-	decr.



27 x : max of $\sqrt{32/27}$ at $\theta = \arcsin(1/\sqrt{3})$, $2\pi - \arcsin(1/\sqrt{3})$; min of $-\sqrt{32/27}$ at $\theta = \pi + \arcsin(1/\sqrt{3})$, $\pi - \arcsin(1/\sqrt{3})$

y : max of 2 at $\theta = \pi/2$; min of -2 at $\theta = 3\pi/2$

29 x : max of $\frac{5}{2}$ at $\theta = 0$; min of $-\frac{9}{16}$ at $\theta = \arccos(-\frac{3}{4})$, $2\pi - \arccos(-\frac{3}{4})$

y : max of $\sin \theta_0(\frac{3}{2} + \cos \theta_0)$ at $\theta = \theta_0 = \arccos\left(\frac{\sqrt{41}-3}{8}\right)$; min of $-\sin \theta_0\left(\frac{3}{2} + \cos \theta_0\right)$

at $\theta = 2\pi - \arccos\left(\frac{\sqrt{41}-3}{8}\right)$

31 $\left(\frac{1}{2}, \frac{\pi}{12}\right), \left(\frac{1}{2}, \frac{5\pi}{12}\right), \left(\frac{1}{2}, \frac{13\pi}{12}\right), \left(\frac{1}{2}, \frac{17\pi}{12}\right), \left(\frac{1}{2}, \frac{7\pi}{12}\right), \left(\frac{1}{2}, \frac{11\pi}{12}\right), \left(\frac{1}{2}, \frac{19\pi}{12}\right), \left(\frac{1}{2}, \frac{23\pi}{12}\right)$

Section 7.9

1 πa^2 3 1 5 $2 - \frac{\pi}{2}$ 7 $\frac{3\pi}{16}$ 9 $\frac{\pi}{4} - \frac{3\sqrt{3}}{8}$ 11 $\frac{\pi}{12} + \frac{\sqrt{3}}{16}$ 13 $\frac{3}{2} - \frac{\pi}{4}$

15 $\frac{\pi}{3} - \frac{\sqrt{3}}{4}$ 17 π^2 19 $\frac{7\pi}{12} - \sqrt{3}$ 21 $\frac{1}{2} \int_a^b (g(\theta))^2 - (f(\theta))^2 d\theta$

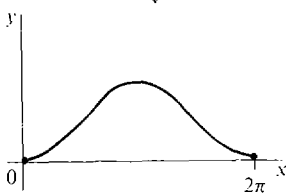
Section 7.10

$$\begin{array}{llll}
 1 & 14\pi & 3 & 2 \\
 5 & \frac{2048 - 493\sqrt{17}}{15} \sim 1.02 & 7 & 4 \\
 9 & 4 & & \\
 11 & \int_0^{2\pi} \sqrt{\sin^2(2\theta) + 4\cos^2(2\theta)} d\theta & 13 & \int_0^b \sqrt{\theta^2 + 1} d\theta \\
 17 & \pi\sqrt{a^2 + b^2} \left(a + \frac{b\pi}{2} \right) & & \\
 19 & \pi\sqrt{2} & 21 & \frac{\pi}{5}(8 - \sqrt{2})
 \end{array}$$

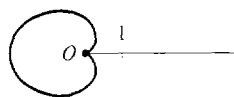
Extra Problems for Chapter 7

$$\begin{array}{llll}
 1 & 1 + \cos x & 3 & \frac{\cos \theta}{2\sqrt{\theta}} - \sqrt{\theta} \sin \theta \\
 5 & 4/3 & 7 & -\sin(\cos \theta) + C \\
 9 & 8 & & \\
 11 & -600/29 \text{ radians/hr} & 13 & -\frac{1}{2\sqrt{x}\sqrt{1-x}} \\
 15 & \frac{1}{1+t^2} - 1 \text{ or } -\frac{t^2}{1+t^2} & 17 & 1 \\
 19 & \operatorname{arcsec}(x-1) + C & 21 & \frac{1}{3}(x^2+1)^{3/2} - (x^2+1)^{1/2} + C = x^2(x^2+1)^{1/2} \\
 & -\frac{2}{3}(x^2+1)^{3/2} + C = (x^2+1)^{1/2}(\frac{1}{3}x^2 - \frac{2}{3}) + C & 23 & 2\sin 1 + 2\cos 1 - 2 \\
 25 & \pi\left(1 - \frac{\pi}{4}\right) & 27 & \frac{\sec^9 \theta}{9} - \frac{2\sec^7 \theta}{7} + \frac{\sec^5 \theta}{5} + C \\
 29 & -\frac{\sqrt{2-x^2}}{x} - \arcsin\left(\frac{x}{\sqrt{2}}\right) + C
 \end{array}$$

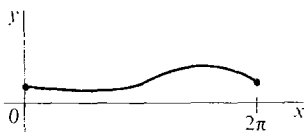
31 (a)



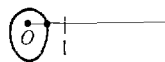
(b)



33 (a)



(b)



$$35 \ 19\pi/8 \quad 37 \ (3\pi/2) - 4 \quad 39 \ 4\sqrt{2}\pi/5$$

Section 8.1

$$9 \ 0 \quad 11 \ \infty \quad 13 \ 0 \quad 15 \ \infty \quad 17 \ 27 \quad 19 \ \infty \quad 21 \ 1/6 \quad 23 \ 1/(2\pi)$$

Section 8.2

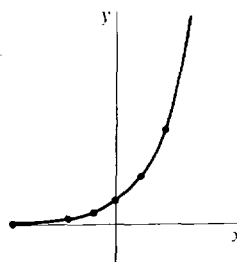
$$\begin{array}{llll}
 1 & x & 3 & -x^2 \\
 5 & x/y^2 & 7 & \frac{2}{3} \log_b x \\
 9 & \frac{1}{2}(\log_b x + \log_b y) & 11 & 2 \\
 13 & 1/2 & & \\
 15 & x = \log_5 3 & 17 & x = -\frac{2}{3} \\
 19 & x = 5^{1/3} & 21 & x = 2, x = 3 \\
 23 & x = 2^{1/(1-\log_3 2)} = 3^{1/(\log_2 3 - 1)} & 25 & -\infty \\
 27 & -\infty & 29 & -\infty
 \end{array}$$

Section 8.3

$$\begin{array}{llll}
 1 & 3e^{3x+4} & 3 & -4^{-x} \ln 4 \\
 5 & e^t \cos(e^t) & 7 & 2^{t^2+1} t \ln 2 \\
 9 & e^t e^{(e^t)} & & \\
 11 & \frac{\ln 3}{2\sqrt{x}} 3^{\sqrt{x}} & 13 & -\frac{e^{x+y}}{e^{x+y} + \sin y} \\
 15 & \frac{1}{2\sqrt{e^t(t^{-1} - t^{-2})}} \text{ or } \frac{t^2}{2\sqrt{e^t(t-1)}} & 17 & \infty \\
 19 & 1 & 21 & -\infty \\
 23 & e^c & 25 & e^c
 \end{array}$$

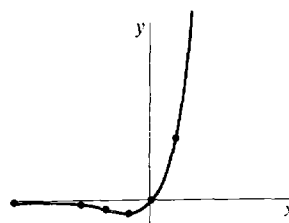
27

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-2	1/4	$(\ln 2)/4$	+	incr.	∪
-1	1/2	$(\ln 2)/2$	+	incr.	∪
0	1	$\ln 2$	+	incr.	∪
1	2	$2 \ln 2$	+	incr.	∪
2	4	$4 \ln 2$	+	incr.	∪
$\lim_{x \rightarrow \infty}$	∞	∞			



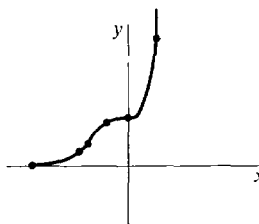
29

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-3	$-3e^{-3}$	$-2e^{-3}$	-	decr.	∩
-2	$-2e^{-2}$	$-e^{-2}$	0	decr.	infl.
-1	$-e^{-1}$	0	+	min.	∪
0	0	1	+	incr.	∪
1	e	$2e$	+	incr.	∪
$\lim_{x \rightarrow \infty}$	∞	∞			



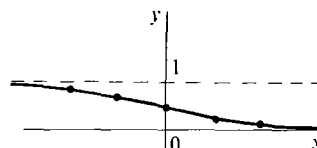
31

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-2	e^{-8}	$12e^{-8}$	+	incr.	∪
-1	e^{-1}	$3e^{-1}$	+	incr.	∪
$-(\frac{2}{3})^{1/3}$	$e^{-2/3}$	+	0	incr.	infl.
$-\frac{1}{2}$	$e^{-1/8}$	$\frac{3}{4}e^{-1/8}$	-	incr.	∪
0	1	0	0	horiz.	infl.
1	e	$3e$	+	incr.	∪
$\lim_{x \rightarrow \infty}$	∞	∞			



33

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	1	0			
-2	0.88	-0.1	-	decr.	∩
-1	0.73	-0.2	-	decr.	∩
0	0.5	-0.25	0	decr.	infl.
1	0.27	-0.2	+	decr.	∪
2	0.12	-0.1	+	decr.	∪
$\lim_{x \rightarrow \infty}$	0	0			



35 $\frac{1}{2}e^{2x} + C$ 37 $-\frac{1}{2}e^{-x^2} + C$ 39 $\frac{1}{3}(1 + e^{2x})^{3/2} + C$ 41 $xe^x - e^x + C$

43 $\frac{1}{2}e^x(\sin x - \cos x) + C$ 45 $\frac{e^{10} - 1}{5}$ 47 ∞

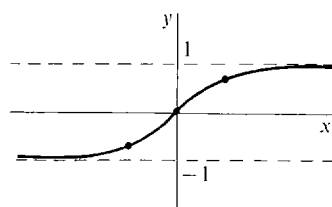
49 $\frac{1}{r^2}$ if $r > 0$, ∞ if $r \leq 0$ 51 (a) $\frac{\pi}{2}(e^2 - 1)$ (b) 2π 53 $\sqrt{2}(e^{2\pi} - 1)$

Section 8.4

1 $3 \cosh(3x)$ 3 $-\tanh x \operatorname{sech} x$ 5 1 7 0

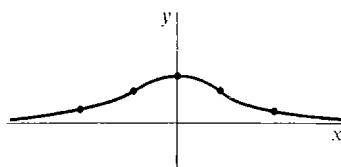
9

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	-1	0			
-1	-0.76	0.4	+	incr.	$\cup$
0	0	1	0	incr.	infl.
1	0.76	0.4	-	incr.	$\cap$
$\lim_{x \rightarrow \infty}$	1	0			



11

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow -\infty}$	0	0			
-2	0.27	0.26	+	incr.	$\cup$
-0.88	0.71	0.5	0	incr.	infl.
0	1	0	-	max.	$\cap$
0.88	0.71	-0.5	0	decr.	infl.
2	0.27	-0.26	+	decr.	$\cup$
$\lim_{x \rightarrow \infty}$	0	0			



13 $\frac{\sinh^2 x}{2} + C$ or $\frac{\cosh^2 x}{2} + C$ 15 $x \cosh x - \sinh x + C$

17 $\frac{1}{2}x \sinh x \cosh x + \frac{1}{4}x^2 - \frac{1}{4}\sinh^2 x + C$ or $\frac{1}{4}x \sinh(2x) - \frac{1}{8}\cosh(2x) + \frac{1}{4}x^2 + C$ 19 ∞

23 (a) $\frac{\pi}{8}(4 + e^2 - e^{-2})$ (b) $2\pi(1 - e^{-1})$ 25 $50,000(e^2 - 1) \sim 320,000$ dollars

27 (a) $10^6(90e^{0.2} - 110) \sim -74,000$ dollars (b) $10^6(90e^{0.3} - 120) \sim 1,490,000$ dollars

Section 8.5

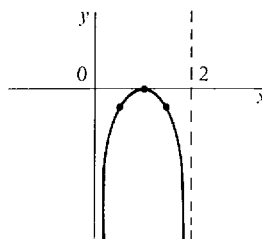
1 $(3/x)(\ln x)^2$ 3 $-\tan x$ 5 $\ln t$ 7 $t^{-2}(1 - \ln t)$ 9 $\frac{1}{x \ln 2}$

11 $\frac{1}{y} + \frac{3}{2(3y+1)}$ 13 $y - \frac{y}{x}$ 15 $\frac{1}{x+y-1}$ 17 0 19 0 21 $\ln a$

23 1 25 1

27

x	$f(x)$	$f'(x)$	$f''(x)$		
$\lim_{x \rightarrow 0^+}$	$-\infty$	∞			
$\frac{1}{2}$	-0.3	$\frac{4}{3}$	-	incr.	$\cup$
1	0	0	-	max.	$\cap$
$\frac{3}{2}$	0.3	$-\frac{4}{3}$	-	decr.	$\cap$
$\lim_{x \rightarrow 2^-}$	$-\infty$	$-\infty$			



29 $\frac{1}{2} \ln |2x + 3| + C$ 31 $2x + 2 \ln |x - 1| + C$ 33 $\frac{1}{2}(\ln x)^2 + C$ 35 $\ln |\ln t| + C$

37 $\ln x(\ln(\ln x) - 1) + C$ 39 $\frac{x^{n+1}}{n+1} \ln x - \frac{x^{n+1}}{(n+1)^2} + C$

41 $x(\ln x)^3 - 3x(\ln x)^2 + 6x \ln x - 6x + C$ 43 $\sin(\ln x) + C$ 45 $10 - \ln(11)$

47 1 49 $-\infty$ 51 ∞ 53 (a) $\pi(e-2)$ (b) $\frac{\pi}{2}(e^2+1)$

55 $\sqrt{e^2+1} - \sqrt{2} + 1 + \ln\left(\frac{1+\sqrt{2}}{1+\sqrt{e^2+1}}\right)$

Section 8.6

1 $y = -\frac{2}{x^2+C}$ 3 $y = \pm\sqrt{\frac{2}{3}x^3+C}$ 5 $y = -\ln\left(\frac{C-x^2}{2}\right)$

7 $y = \ln(e^x+C)$ 9 $y = \frac{1}{\pm\sqrt{2\cos x+C}}$ 11 $y = \frac{x^3}{3} + \frac{x^2}{2} + Ax+B$

13 $y = Ax+B$ 15 $y = A\sinh(\sqrt{3}x) + B\cosh(\sqrt{3}x)$ or $y = Ae^{\sqrt{3}x} + Be^{-\sqrt{3}x}$

17 $y = 10^7 e^{(0.01)t}$ 19 $\frac{6\ln 10}{\ln 2} \text{ min} \sim 19.93 \text{ min}$ 21 $10^5 \times (1.15)^4 \sim 174,900$

23 $t = \frac{\ln(0.5)}{\ln(0.9)} \sim 6.576 \text{ years}$ 25 $y = e^t + e^{-t}$ 27 $y = \cos t - 2\sin t$

29 $y = 10^{6.5}\sqrt{t}$ 31 $y = \frac{10^8}{1+9e^{-t}}$ 33 (b) $y_0 = L/2$

35 (a) $y = 10^7 - 6 \times 10^6 2^{-t}$ (b) $y = 10^7 + 3 \times 10^6 3^{-t}$

37 $y^2 - x^2 = C$ or $y = \pm\sqrt{x^2+C}$

Section 8.7

1 $\left(\frac{3x-2}{4x+3}\right)\left[\frac{3}{3x-2} - \frac{4}{4x+3}\right]$

3 $\frac{(x^2+1)\sqrt{3x+4}}{(2x-3)\sqrt{x^2-4}}\left[\frac{2x}{x^2+1} + \frac{3}{2(3x+4)} - \frac{2}{2x-3} - \frac{x}{x^2-4}\right]$

5 $(x-1)^{x^2+1}\left[2x\ln(x-1) + \frac{x^2+1}{x-1}\right]$ 7 $e^{(e^x)}e^x$ 9 $\sqrt[3]{t}\left[\frac{1}{t^2} - \frac{1}{t^2}\ln t\right]$

11	x	$f(x)$	$f'(x)$	$f''(x)$		
	$\lim_{x \rightarrow 0^+}$	1	$-\infty$			
	1/10	$10^{-0.1}$	-	+	decr.	∪
	1/e	$e^{-1/e}$	0	+	min.	∪
	1	1	1	+	incr.	∪
	$\lim_{x \rightarrow \infty}$	∞	∞			



15 $\ln|\sin \theta| + C$ 17 $\frac{1}{3}\ln|\sec(3\theta)| + C$

19 $\frac{1}{4}\sec^4 \theta \sin \theta + \frac{3}{8}\sec^2 \theta \sin \theta + \frac{3}{8}\ln|\sec \theta + \tan \theta| + C$ 21 $\ln|\tan x| + C$

23 $\ln|\sec x + \tan x| - \sin x + C$ 25 $\frac{1}{2}x\sqrt{x^2-1} - \frac{1}{2}\ln|x+\sqrt{x^2-1}| + C$

27 $\frac{1}{2}\ln\left|\frac{x}{\sqrt{4-x^2}+2}\right| + C$ or $\frac{1}{4}\ln\left|\frac{2-\sqrt{4-x^2}}{2+\sqrt{4-x^2}}\right| + C$ 29 $\frac{1}{4}\ln\left|\frac{x-2}{x+2}\right| + C$

31 $\sqrt{x^2-1} - \operatorname{arcsec} x + C$ or $\sqrt{x^2-1} - \arctan \sqrt{x^2-1} + C$

33 $\frac{x}{4}(x^2+1)^{3/2} - \frac{x}{8}(x^2+1)^{1/2} - \frac{1}{8}\ln(x+\sqrt{x^2+1}) + C$ or

$x(x^2+1)^{1/2}\left(\frac{1}{4}x^2 + \frac{1}{8}\right) - \frac{1}{8}\ln(x+\sqrt{x^2+1}) + C$

- 35 $-\frac{\arcsin x}{x} - \ln \left| \frac{1 + \sqrt{1-x^2}}{x} \right| + C$ or $-\frac{\arcsin x}{x} + \ln \left| \frac{1 - \sqrt{1-x^2}}{x} \right| + C$
 37 $x \operatorname{arccsc} x + \ln(x + \sqrt{x^2 - 1}) + C, x \geq 1; x \operatorname{arccsc} x - \ln|x + \sqrt{x^2 - 1}| + C, x \leq -1$
 39 $\sqrt{5} + \frac{1}{2} \ln(2 + \sqrt{5}) \sim 2.96$ 41 $\frac{1}{2}a\sqrt{1+a^2} + \frac{1}{2} \ln(a + \sqrt{1+a^2})$

Section 8.8

- 1 $\frac{1}{2} \ln|2x-7| + C$ 3 $\frac{1}{12} \ln|x-4| - \frac{1}{12} \ln|x| + C$ 5 $-\frac{1}{5} \ln|x-1| + \frac{1}{5} \ln|x+4| + C$
 7 $\frac{x^2}{2} - 3x + \frac{1}{4} \ln|x| + \frac{5}{4} \ln|x+4| + C$ 9 $-\frac{1}{2(x+1)^2} + C$
 11 $\ln|x-1| - \frac{1}{x-1} - \frac{1}{2(x-1)^2} + C$ 13 $-\ln|x| + \frac{1}{2} \ln|x+1| + \frac{1}{2} \ln|x-1| + C$
 15 $x + \ln|x| - \frac{1}{x} + C$ 17 $x - 4 \arctan(x/4) + C$ 19 $\frac{5}{4} \ln|x-3| - \frac{1}{4} \ln|x+1| + C$
 21 $\frac{1}{3}x^3 - x + \arctan x + C$ 23 $\arctan x - (1/\sqrt{2}) \arctan(x/\sqrt{2}) + C$
 25 $-x^{-1} - \arctan x + C$ 27 $\frac{1}{3} \ln|x+1| - \frac{1}{6} \ln|x^2-x+1| + \frac{1}{\sqrt{3}} \arctan\left(\frac{2x-1}{\sqrt{3}}\right) + C$
 29 $\frac{x^2}{2} - \frac{3}{4} \ln|x+1| + \frac{5}{4} \ln|x-1| - \frac{1}{4} \ln|x^2+1| + \arctan x + C$
 31 $\ln|x| - \frac{1}{2} \ln|x^2+1| - \frac{\arctan x}{x} + C$

Section 8.9

- 1 $-3 \cos x + 4 \sin x + C$ 3 $\frac{3}{4}(x^2-1)^{2/3} + C$ 5 $\frac{1}{3}[(x+2)^{3/2} + x^{3/2}] + C$
 7 $2(1+\sqrt{x}) - 2 \ln(1+\sqrt{x}) + C$ or $2\sqrt{x} - 2 \ln(1+\sqrt{x}) + C$
 9 $-(\sqrt{4x+1}/x) + C$ 11 $-2 \cos(\sqrt{x}) + C$
 13 $\frac{2}{3}(x-3)^{7/2} + \frac{12}{5}(x-3)^{5/2} + 6(x-3)^{3/2} + C$
 15 $\frac{1}{3}[(3x+4) \ln(3x+4) - (3x+4)] + C$ or $\frac{1}{3}(3x+4) \ln(3x+4) - x + C$
 17 $x \tan x - \ln|\sec x| - (x^2/2) + C$ 19 $-\frac{1}{6} \cos(3x^2+1) + C$
 21 $2x \ln|x| - 3x + (x+1) \ln(x+1) + C$ 23 $\cos \theta - \cos \theta \ln(\cos \theta) + C$
 25 $\ln(2 - \cos \theta) + C$ 27 $\frac{1}{4}(e^x+1)^4 + C$ 29 $2 \sin(\sqrt{x}) - 2\sqrt{x} \cos(\sqrt{x}) + C$
 31 $\ln(1 + \cosh x) + C$ 33 $-\frac{\ln x}{1+x} + \ln\left(\frac{x}{1+x}\right) + C$
 35 $\frac{4}{5}(1 - \cos x)^{5/2} - \frac{2}{7}(1 - \cos x)^{7/2} + C$ 37 $\frac{1}{\sqrt{2}} \ln \left| \frac{x}{\sqrt{2} + \sqrt{2+x^2}} \right| + C$
 39 $4 \arcsin\left(\frac{\sqrt{x}}{2}\right) + \sqrt{x}\sqrt{4-x} - \frac{1}{2}\sqrt{x}(4-x)^{3/2} + C$ or $\frac{1}{2}(x-2)\sqrt{x}\sqrt{4-x} + 2 \arcsin\left(\frac{x-2}{2}\right) + C$
 41 $\frac{1}{5}[(5x-2) \arcsin(5x-2) + \sqrt{1-(5x-2)^2}] + C$ 43 $\frac{1}{2}e^x(\sin x + \cos x) + C$
 45 $(x^3/3) - x + 2 \arctan x + C$ 47 $\frac{1}{2}x^2 \operatorname{arcsec}(x^2) - \frac{1}{2} \ln(x^2 + \sqrt{x^4-1}) + C$
 49 $2x \ln x + \frac{4x-1}{8} \ln(4x-1) - \frac{5}{2}x + C$ 51 $2 \ln|2x + \sqrt{4x^2-1}| - \frac{\sqrt{4x^2-1}}{x} + C$
 53 $(x+1) \arctan(\sqrt{x}) - \sqrt{x} + C$ 55 $\frac{1}{8} \ln|\sec(4x^2+7) + \tan(4x^2+7)| + C$
 57 $-\frac{1}{243}\sqrt{1-9x^2}(2+9x^2) + C$ 59 $(\sqrt{x^2-3}/3x) + C$
 61 $3x^{2/3} \sin(\sqrt[3]{x}) + 6(\sqrt[3]{x}) \cos(\sqrt[3]{x}) - 6 \sin(\sqrt[3]{x}) + C$
 63 $\frac{1}{3}x^3(1-x^2)^{-3/2} + x(1-x^2)^{-1/2} + C$ 65 $\frac{x}{5}(\cos^2(\ln x) + \sin(2 \ln x) + 2) + C$

Extra Problems for Chapter 8

- 1 $-\infty$ 3 $-e^{\cos \theta} \sin \theta$ 5 $-3 \operatorname{csch}^3 x \coth x$ 7 $-\frac{1}{\ln 3} \cos(3^x) + C$
 9 $\frac{1}{2}e^x \sqrt{1 - e^{2x}} + \frac{1}{2} \arcsin(e^x) + C$ or $\frac{1}{2}e^x \sqrt{1 - e^{2x}} - \frac{1}{2} \arccos(e^x) + C$
 11 $\frac{1}{4}e^{2x} - \frac{1}{2}x + C$ 13 $\frac{8x}{x^2 - 1}$ 15 $\frac{3}{3x + 2} + \frac{5}{5x - 4} - \frac{2}{2x - 1} - \frac{2x}{x^2 + 1}$ 17 e^2
 19 $(1/a) \ln |x| - (b/a) \ln |a + bx| + C$ 21 ∞ 23 $y = \pm \sqrt{ax^2 + C}$
 25 $P = CV^{-1/k}$ 27 air temp. $= 60^\circ$, $y = 60 + 80 \cdot 2^{-t/10}$
 29 $(4t + 1)^4(t - 3)^{2t+1} \left\{ \ln[(t - 3)^2(4t + 1)] + \frac{4t}{4t + 1} + \frac{2t + 1}{t - 3} \right\}$ 31 $\ln |\cosh x| + C$
 33 $\frac{2}{3}(x + 1)^{5/2} + C$ 35 $\pi(2\sqrt{2} + \ln|\sqrt{2} + 1| - \ln|\sqrt{2} - 1|)$ or $2\pi(\sqrt{2} + \ln|\sqrt{2} + 1|)$
 37 $e^{0.03} \sim 1.03$, error ≤ 0.0005 39 $\ln 6 \sim \frac{1}{2} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{5} + \frac{1}{12} = \frac{28}{15}$, error $\leq \frac{1}{2}$
 41 $\bar{x} = \frac{2 \ln 2 - \frac{3}{4}}{2 \ln 2 - 1}$, $\bar{y} = \frac{(\ln 2 - 1)^2}{2 \ln 2 - 1}$
 43 $\pi[e\sqrt{1 + e^2} - \sqrt{2} + \ln(e + \sqrt{1 + e^2}) - \ln(1 + \sqrt{2})]$

Section 9.1

- 1 2^{-n} 3 $(-1)^n n$ 5 $2 - (1/2^{n-1})$ 7 $2^{2^{(n-1)}}$ 9 diverges 11 1
 13 0 15 diverges 17 diverges 19 $1/e$ 21 0 23 -1 25 diverges
 27 diverges 29 0

Section 9.2

- 1 $\frac{3}{2}(1 - (1/3)^n)$, converges to $\frac{3}{2}$ 3 $4(1 - (3/4)^n)$, converges to 4
 5 $1 - \frac{1}{(n+1)!}$, converges to 1 7 $1 - \frac{1}{n+1}$, converges to 1
 9 n even: $-\frac{n}{2}$, n odd: $\frac{n}{2} + \frac{1}{2}$, diverges 11 $1 - (n+1)^{-2}$, converges to 1
 13 $\frac{1}{2}\left(1 - \frac{1}{2n+1}\right)$, converges to $\frac{1}{2}$ 15 diverges because $\lim_{n \rightarrow \infty} a_n = \frac{1}{2}$
 17 diverges because for infinite H , $S_{2H} \not\approx S_{2 \cdot 2H}$
 19 diverges because for infinite H , $S_{2H} \not\approx S_H$ 21 $A: 2/3$, $B: 1/3$
 23 $A: 9/19$, $B: 6/19$; $C: 4/19$

Section 9.3

- 1 $1/42$ 3 $11/4$ 5 $5/48$ 7 $216/5$ 9 $80/9$ 11 $\frac{543}{99}$
 13 $492.315 + (41/999,000)$ 15 $1/7$

Section 9.4

- 1 diverges 3 converges 5 converges 7 converges 9 diverges
 11 diverges 13 converges 15 diverges 17 converges 19 converges
 21 diverges 23 converges 25 converges 27 diverges 29 diverges
 31 converges 33 diverges 35 converges 37 converges

Section 9.5

- 1 diverges 3 diverges 5 converges 7 diverges 9 diverges
 11 diverges 13 converges 15 converges 17 converges 19 diverges
 21 0.90 23 0.37

Section 9.6

- 1 diverges 3 diverges 5 absolutely converges 7 diverges 9 diverges
 11 diverges 13 conditionally converges 15 absolutely converges
 17 conditionally converges 19 diverges 21 diverges 23 no information
 25 converges 27 diverges 29 converges 31 converges 33 no information
 35 converges 37 converges 39 converges 41 no information 43 converges

Section 9.7

- 1 1 3 0 5 e 7 $4/e^2$ 9 1 11 1 13 0 15 $1/3$ 17 ∞
 19 ∞ 21 0 23 $\sqrt[3]{5}$ 25 1 27 $(-1, 1)$ 29 $(-1, 1]$ 31 $[-1/2, 1/2)$
 33 $(-\infty, \infty)$ 35 $(-3, -1]$ 37 $(-\infty, \infty)$ 39 $(-1, 1)$ 41 $(-5/4, 5/4)$
 43 $(-\sqrt{5}, \sqrt{5})$ 45 $(-\infty, \infty)$

Section 9.8

- 1 $f'(x) = \sum_{n=1}^{\infty} n 10^n x^{n-1}, \int_0^x f(t) dt = \sum_{n=0}^{\infty} \frac{10^n}{n+1} x^{n+1}$
 3 $f'(x) = \sum_{n=1}^{\infty} n^{-2} x^{n-1}, \int_0^x f(t) dt = \sum_{n=1}^{\infty} \frac{n^{-3}}{n+1} x^{n+1}$
 5 $f'(x) = \sum_{n=1}^{\infty} (n+1)x^{n-1}, \int_0^x f(t) dt = \sum_{n=1}^{\infty} \frac{1}{n} x^{n+1}$
 7 $f'(x) = \sum_{n=1}^{\infty} \frac{n!}{n^{n-1}} x^{n-1}, \int_0^x f(t) dt = \sum_{n=1}^{\infty} \frac{n!}{n^n(n+1)} x^{n+1}$
 9 $f'(x) = \sum_{n=1}^{\infty} 2n x^{2n-1}, \int_0^x f(t) dt = \sum_{n=0}^{\infty} \frac{1}{2n+1} x^{2n+1}$ 11 $\sum_{n=0}^{\infty} (-1)^n 3^n x^n, r = \frac{1}{3}$
 13 $\sum_{n=0}^{\infty} \frac{(-1)^n 4^{2n+1} x^{4n+2}}{2n+1}, r = \frac{1}{2}$ 15 $\sum_{n=0}^{\infty} \frac{(-1)^n 2^{n+1} x^{n+2}}{n+1}, r = \frac{1}{2}$
 17 $\sum_{n=0}^{\infty} \frac{(-1)^n 4^n x^n}{n!}, r = \infty$ 19 $\sum_{n=0}^{\infty} \frac{3^{2n+1} x^{2n+1}}{(2n+1)!}, r = \infty$
 21 $\sum_{n=0}^{\infty} \frac{(-1)^n 2^{n+1} x^{2n+3}}{(n+1)(2n+3)}, r = \frac{1}{\sqrt{2}}$ 23 $\sum_{n=0}^{\infty} \frac{x^{3n+1}}{n!(3n+1)}, r = \infty$
 25 $\sum_{n=0}^{\infty} \frac{x^{n+3}}{(n+1)(n+3)}, r = 1$ 27 $\sum_{n=0}^{\infty} \frac{(-1)^n x^{n+1}}{(n+1)^2}, r = 1$
 29 $\sum_{n=1}^{\infty} (-1)^{n+1} 2n x^{2n-1}, r = 1$ 31 $\sum_{n=0}^{\infty} (-1)^n 2 \cdot x^{4n+1}, r = 1$
 33 $\sum_{n=0}^{\infty} \frac{(-1)^n (1 + 2^{2n+1}) x^{2n+1}}{2n+1}, r = \frac{1}{2}$

Section 9.9

- 1 0.18232 3 0.7788008 5 0.4854019 7 0.3293740 9 1.003009
 11 1.098614 13 $f(x) = x + x^2 + \cdots + x^{n+1} + E, |E| \leq 2|x|^{n+2}, f(\frac{1}{2}) = 1$
 15 $f(x) = 1 + x^2 + \cdots + x^{2n} + E, |E| \leq \frac{4}{3}x^{2n+2}, f(\frac{1}{2}) = \frac{4}{3}$
 17 $f(x) = -x - (x^2/2^2) - \cdots - (x^n/n^2) + E, |E| \leq 2|x|^{n+1}/(n+1)^2, f(\frac{1}{2}) \sim 0.58$

Section 9.10

- 1 $f(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \cdots + \frac{(-1)^n x^{2n}}{(2n)!} + \frac{(-1)^{n+1} (\cos t) x^{2n+2}}{(2n+2)!}, f\left(\frac{1}{2}\right) \sim 0.8776$

- 3 $f(x) = 2x - \frac{2^3 x^3}{3!} + \cdots + \frac{(-1)^{n+1} 2^{2n+1} x^{2n+1}}{(2n+1)!} + \frac{(-1)^n \cos(2t) (2x)^{2n+3}}{(2n+3)!}, f\left(\frac{1}{2}\right) \sim 0.8415$
- 5 $f(x) = x - \frac{4x^3}{3!} + \frac{4^2 x^5}{5!} - \cdots + \frac{(-1)^n 4^n x^{2n+1}}{(2n+1)!} + \frac{(-1)^{n+1} 4^{n+1} (\cos^2 t - \sin^2 t) x^{2n+3}}{(2n+3)!},$
 $f\left(\frac{1}{2}\right) \sim 0.4207$
- 7 $f(x) = 2^{-3} + 3 \cdot 2^{-6} x + \cdots + \frac{(-1)^n (1 \cdot 3 \cdots (2n+1)) 2^{-3(n+1)} x^n}{n!}$
 $+ \frac{(-1)^{n+1} (1 \cdot 3 \cdots (2n+3)) (4+t)^{(-5/2-n)} x^{n+1}}{2^{n+1} (n+1)!}, f\left(\frac{1}{2}\right) \sim 0.1048$
- 9 $x + \frac{x^3}{3}, 0.346$ 11 $x + \frac{x^3}{6}, 0.340$ 13 $x - \frac{x^2}{2}, 0.28$ 15 $x + \frac{x^3}{3}, 0.346$
- 17 $\frac{x^2}{2} - \frac{x^3}{6}, 0.049$
- 19 $e^x = e^2 + e^2(x-2) + \frac{e^2(x-2)^2}{2!} + \cdots + \frac{e^2(x-2)^n}{n!} + \frac{e^t(x-2)^{n+1}}{(n+1)!}$
- 21 $x^p = 1 + p(x-1) + \frac{p(p-1)(x-1)^2}{2} + \cdots + \frac{p(p-1) \cdots (p-n+1)(x-1)^n}{n!}$
 $+ \frac{p(p-1) \cdots (p-n)t^{p-n-1}(x-1)^{n+1}}{(n+1)!}$

Section 9.11

- 1 96 3 6 5 1008 7 $\sum_{n=0}^{\infty} x^n / (2^n n!), r = \infty$
- 9 $1 + x + \sum_{n=2}^{\infty} \frac{(-1)^{n+1} (1 \cdot 3 \cdot 5 \cdots (2n-3)) x^n}{n!}, r = \frac{1}{2}$
- 11 $\sum_{n=0}^{\infty} \frac{(-1)^n x^n}{(2n)!}$, converges to $\cos \sqrt{x}$ for $x \geq 0$ 13 $\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n}}{(2n+1)!}, r = \infty$
- 15 $1 - \frac{x^2}{2} + \sum_{n=2}^{\infty} -\frac{(1 \cdot 3 \cdot 5 \cdots (2n-3)) x^{2n}}{2^n n!}, r = 1$ 17 $\sum_{n=0}^{\infty} \frac{(-1)^n x^{6n+4}}{(6n+4)(2n+1)!}, r = \infty$
- 19 $\sum_{n=0}^{\infty} \frac{x^{4n+1}}{(4n+1)(2n+1)!}, r = \infty$ 21 $x + \sum_{n=1}^{\infty} \frac{\frac{1}{3}(\frac{1}{3}-1) \cdots (\frac{1}{3}-n+1) x^{2n+1}}{n!(2n+1)}, r = 1$
- 23 $x + \sum_{n=1}^{\infty} \frac{1 \cdot 3 \cdots (2n-1) x^{2n+1}}{2^n n! (2n+1)^2}, r = 1$ 25 $\sum_{n=1}^{\infty} \frac{(-1)^{n+1} (x-1)^n}{n}, r = 1$

Extra Problems for Chapter 9

- 1 converges to 1 3 converges to 1 5 diverges to ∞ 7 diverges
- 9 converges to $28\frac{4}{15}$ 11 converges to 42 13 diverges 15 diverges
- 17 converges 19 converges 21 diverges 23 converges 25 converges
- 27 converges 29 diverges 31 $1/2$ 33 1 35 $\sqrt{e}$
- 37 $f'(x) = \sum_{n=1}^{\infty} n^{a+1} (n+1)^b 2^n x^{n-1}, \int_0^x f(t) dt = \sum_{n=1}^{\infty} n^a (n+1)^{b-1} 2^n x^{n+1}, r = \frac{1}{2}$
- 39 $\sum_{n=0}^{\infty} \frac{(-1)^n x^{4n+1}}{(2n+1)(4n+1)!}, r = 1$ 41 -0.006 43 0.646
- 45 $x + \sum_{n=1}^{\infty} \frac{2^n (-1)^n (2 \cdot 5 \cdot 8 \cdots (3n-1)) x^{2n+1}}{3^n (2n+1)n!}, r = \frac{1}{\sqrt{2}}$ 47 e^{50}

Section 10.1

- 1 $i + 2j$ 3 $-3i - 4j$ 5 $(2, -4)$ 7 $(-1, 12)$ 9 $A + B = -3i + j$
- 11 $A + B + C = j$ 13 $3A = 3i - 6j$ 15 $B - A = -5i + 5j$

17 $A - 2B + 3C = 18i - 8j$ 19 $|B| = 5$ 21 $|A - B| = 5\sqrt{2}$ 23 $|6A| = 6\sqrt{5}$
 25 $\frac{13}{4}i - \frac{5}{4}j$ 27 $-\frac{4}{3}i + \frac{2}{3}j, (-\frac{4}{3}, \frac{2}{3})$ 29 $\arccos(-(2\sqrt{5})/5)$ 31 $\arccos(-\frac{4}{5})$
 33 $7i + 3j$ 35 $8i - 2j$ 37 $-4i - 6j$ 39 5 41 $4i + 3j$ 43 $10i + 2j$
 45 $-2\sqrt{2}i + 2\sqrt{2}j$ 47 $6i + 8j$ 49 $2i - j, 2i + 2j, -5i + 2j, i - 3j$

Section 10.2

1 $X = 3i - j + t(-i + j)$ 3 $X = 3i + 4j + t(-2i + 5j)$ 5 $X = i + 4j + t(i - 5j)$
 7 $X = 2i + 5j + tj$ 9 $X = 2j + t(i + 5j)$ 11 $X = 3j + ti$
 13 $X = 6i + 5j + t(i - 3j)$ 15 $y = -2x + 10$ 17 $y = 3$ 19 no 21 yes
 23 yes 25 $(-2, 3)$ 27 $(2, 10)$ 29 $(4, 3)$

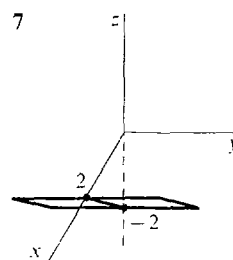
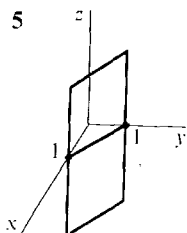
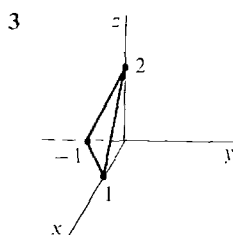
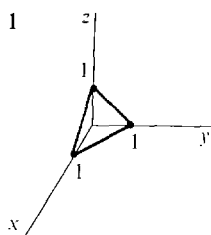
Section 10.3

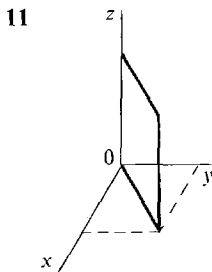
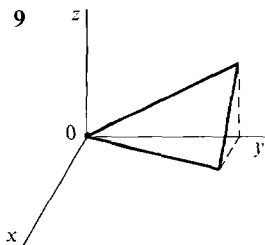
1 $5i - j + 7k$ 3 $-k$ 5 $(0, 0, 0)$ 7 $3i + j - 4k$ 9 $i + 5j - 8k$
 11 $-2i - 3j + 6k$ 13 3 15 $\sqrt{26}$ 17 $\arccos(\frac{8}{21})$ 19 0
 21 $\frac{1}{3}i - \frac{2}{3}j + \frac{2}{3}k, (\frac{1}{3}, -\frac{2}{3}, \frac{2}{3})$ 23 $-3i + 3j + 3\sqrt{2}k$ 25 $\frac{2}{3}, -\frac{2}{3}$ 27 $\frac{3}{10}i - \frac{1}{2}j + \frac{1}{10}k$
 29 $125i + 250j + 625k$ 31 $X = i + 3j + k + t(i - k)$
 33 $X = -i + 4j + 3k + t(-i - 7j + 3k)$ 35 $X = t(-3i + 4k)$

Section 10.4

1 (a) 20 (b) $A \parallel B$ (c) 1 3 (a) 0 (b) $A \perp B$ (c) 0
 5 (a) 24 (b) neither (c) $12/37$ 7 (a) -92 (b) neither (c) $-92/117$
 9 (a) 0 (b) $A \perp B$ (c) 0 11 (a) $8\sqrt{5}$ (b) $A \parallel B$ (c) 1 13 41
 15 $3i + 3j + 3k$ 17 $200\sqrt{2}$ 19 $i - j$ 21 $-2i - 2j - 4k$ 23 $-i + j + k$
 25 $-i - j + k$ 27 $\frac{4}{3}i + \frac{2}{3}j$ 29 $i - j$ 31 $\arccos(\frac{1}{3})$ 33 $\pi/3$

Section 10.5





- 13 (a) $\mathbf{i} - 3\mathbf{j} + 6\mathbf{k}$ (b) $\mathbf{i} + 2\mathbf{j}$ (c) $-3\mathbf{i} + 4\mathbf{j} + \mathbf{k}$ (d) $\mathbf{i} + 6\mathbf{k}$ (e) $\mathbf{j}$ (f) $-\mathbf{j} + \mathbf{k}$
 15 $y + 2z = -9$ 17 $x + y + 2z = 0$ 19 $y - z = -1$
 21 $4x + 20y - 5z = 20$ 23 $x + 2y + z = 9$ 25 $2x + y + 3z = 13$
 27 $x + y - 2z = 20$ 29 $x - y - 3z = 3$ 31 $24x - 19y + 4z = 57$ 33 parallel
 35 neither 37 $\mathbf{X} = 5\mathbf{i} + 3\mathbf{j} - \mathbf{k} + t(\mathbf{i} - \mathbf{j} + 3\mathbf{k})$ 39 $\mathbf{X} = -\mathbf{i} + \mathbf{k} + t(3\mathbf{i} - \mathbf{j} - 2\mathbf{k})$
 41 $\mathbf{X} = \mathbf{j} - \mathbf{k} + t(-\mathbf{i} + \mathbf{j} + \mathbf{k})$ 43 $(3, 1, 1)$ 45 $(-\frac{4}{3}, 0, \frac{8}{3})$ 47 $(-2, 1, 2)$
 49 $(1, 1, 3)$

Section 10.6

- 1 $\mathbf{X} = 3t\mathbf{i} + 9t^2\mathbf{j}$ 3 $\mathbf{X} = \frac{1}{\sqrt{5}}t^3\mathbf{i} + \frac{2}{\sqrt{5}}t^3\mathbf{j}$ 5 $\mathbf{X} = (1/\sqrt{t^2 + 1})(t\mathbf{i} + \mathbf{j})$
 7 $\mathbf{X} = \frac{\cos t + \cos(3t)}{2}\mathbf{i} + \frac{\sin t + \sin(3t)}{2}\mathbf{j}$
 9 $\mathbf{X} = (4 \cos(t/3) - \cos(4t/3))\mathbf{i} + (4 \sin(t/3) - \sin(4t/3))\mathbf{j}$
 11 $\mathbf{X} = (\cos t + t \sin t)\mathbf{i} + (\sin t - t \cos t)\mathbf{j}$ 13 $\mathbf{X} = \cos t\mathbf{i} + \sin t\mathbf{j} + t^2\mathbf{k}$
 15 $\mathbf{X} = \mathbf{i} + \left(2 + \frac{t^2}{\sqrt{2t^4 - 2t^2 + 1}}\right)\mathbf{j} + \left(1 + \frac{t^2 - 1}{\sqrt{2t^4 - 2t^2 + 1}}\right)\mathbf{k}$
 17 $\mathbf{X} = \frac{1}{2}(\cos t + \cos(2t))\mathbf{i} + \frac{1}{2}\sin t\mathbf{j} + \frac{1}{2}\sin(2t)\mathbf{k}$
 19 $\mathbf{X} = (-\frac{5}{3} + \frac{2}{3}\cos t - \frac{1}{3}\sin t)\mathbf{i} + (-\frac{5}{3} - \frac{1}{3}\cos t + \frac{2}{3}\sin t)\mathbf{j} + (\frac{1}{3} - \frac{1}{3}\cos t - \frac{1}{3}\sin t)\mathbf{k}$
 21 $\mathbf{X} = (t - t \cos^2 t - 2t \sin t \cos t)\mathbf{i} + (2t - t \sin t \cos t - 2t \sin^2 t)\mathbf{j} + 3t\mathbf{k}$
 23 $\mathbf{P}(t) = 2t\mathbf{i} + \frac{1}{2t(t+1)}\mathbf{j} + (t+1)\mathbf{k}$

Section 10.7

- 1 $5 \cos t\mathbf{i} - 5 \sin t\mathbf{j}$ 3 $-e^t \sin(e^t)\mathbf{i} + e^t \cos(e^t)\mathbf{j}$ 5 $-6\mathbf{i} + (6/t)\mathbf{j} - 6e^t\mathbf{k}$
 7 $2 \cos 2t$ 9 $t/\sqrt{1+t^2}$ 11 $\mathbf{i} + \mathbf{j} + \mathbf{k} + t(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$
 13 $\mathbf{V} = 2\mathbf{i} + 3\mathbf{j} - 4\mathbf{k}$, $|\mathbf{V}| = \sqrt{29}$, $\mathbf{A} = \mathbf{0}$
 15 $\mathbf{V} = -\sin t\mathbf{i} + \cos t\mathbf{j} + \mathbf{k}$, $|\mathbf{V}| = \sqrt{2}$, $\mathbf{A} = -\cos t\mathbf{i} - \sin t\mathbf{j}$
 17 $\mathbf{V} = -e^t \sin(e^t)\mathbf{i} + e^t \cos(e^t)\mathbf{j}$, $|\mathbf{V}| = e^t$,
 $\mathbf{A} = (-e^t \sin e^t - e^{2t} \cos e^t)\mathbf{i} + (e^t \cos e^t - e^{2t} \sin e^t)\mathbf{j}$
 19 $\mathbf{V} = 2t\mathbf{i} + 4t\mathbf{j} - 2t\mathbf{k}$, $|\mathbf{V}| = 2\sqrt{6}|t|$, $\mathbf{A} = 2\mathbf{i} + 4\mathbf{j} - 2\mathbf{k}$
 21 $\mathbf{S} = t \cos t\mathbf{i} + t \sin t\mathbf{j}$, $\mathbf{V} = (-t \sin t + \cos t)\mathbf{i} + (t \cos t + \sin t)\mathbf{j}$, $|\mathbf{V}| = \sqrt{1+t^2}$,
 $\mathbf{A} = (-t \cos t - 2 \sin t)\mathbf{i} + (-t \sin t + 2 \cos t)\mathbf{j}$
 23 $\mathbf{S} = \cos(t^2)\mathbf{i} + \sin(t^2)\mathbf{j}$, $\mathbf{V} = -2t \sin(t^2)\mathbf{i} + 2t \cos(t^2)\mathbf{j}$, $|\mathbf{V}| = |2t|$,
 $\mathbf{A} = (-2 \sin(t^2) - 4t^2 \cos(t^2))\mathbf{i} + (2 \cos(t^2) - 4t^2 \sin(t^2))\mathbf{j}$
 25 $\mathbf{V} = (e^x/\sqrt{1+e^{2x}})\mathbf{i} + (e^{2x}/\sqrt{1+e^{2x}})\mathbf{j}$, $|\mathbf{V}| = e^x$,
 $\mathbf{A} = [-e^{3x}(1+e^{2x})^{-3/2} + e^x(1+e^{2x})^{-1/2}]\mathbf{i} + [-e^{4x}(1+e^{2x})^{-3/2} + 2e^{2x}(1+e^{2x})^{-1/2}]\mathbf{j}$
 27 2π 29 5 31 $2\sqrt{3} + \sqrt{2} \ln(\sqrt{3} + \sqrt{2})$ 33 $\frac{3}{2} + \ln 2$
 35 $\mathbf{F}(t) = (\frac{1}{2}t^2 + \frac{1}{2})\mathbf{i} + (\frac{1}{3}t^3 + \frac{5}{3})\mathbf{j} + (\frac{1}{4}t^4 + \frac{11}{4})\mathbf{k}$

$$37 \quad \mathbf{F}(t) = \ln|t-1|\mathbf{i} + (\ln|t-2| - \ln 2)\mathbf{j} + (\ln|t-3| - \ln 3)\mathbf{k}$$

$$39 \quad \mathbf{S} = (t - \sin t)\mathbf{i} + (1 - \cos t)\mathbf{j} + \frac{1}{2}t^2\mathbf{k}$$

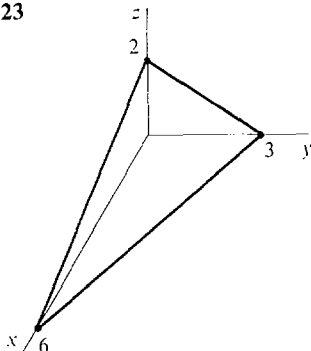
Section 10.8

- 1 infinitesimal 3 infinite 5 finite 7 infinite 9 infinite
 11 infinitesimal (zero) 13 infinite 15 infinite 17 infinitesimal 19 infinite
 21 $-\sin x\mathbf{i} + \cos x\mathbf{j}$ 23 $10\mathbf{i} - 20\mathbf{j} + 5\mathbf{k}$ 25 $2\mathbf{i} + 3\mathbf{j} - \mathbf{k}$ 27 0
 29 $(1/|\mathbf{A}|)\mathbf{A} \cdot \mathbf{U}$ if $\mathbf{A} \neq \mathbf{0}$, 1 if $\mathbf{A} = \mathbf{0}$ 31 (a) no (b) no 33 (a) yes (b) no
 35 (a) yes (b) no 37 (a) no (b) no 39 (a) yes (b) no

Extra Problems for Chapter 10

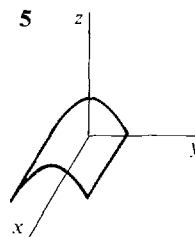
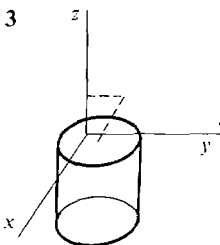
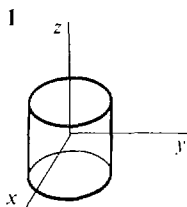
- 1 $5\mathbf{i} - 12\mathbf{j}$ 3 $-3\mathbf{i} - 3\mathbf{j}$ 5 $9\mathbf{i} + 11\mathbf{j}$ 7 $\mathbf{X} = -\mathbf{i} + \mathbf{j} + t(4\mathbf{i} - 3\mathbf{j})$ 9 $(2, 5/2)$
 11 $(1/\sqrt{105}, -10/\sqrt{105}, 2/\sqrt{105})$ 13 $100\mathbf{i} - 500\mathbf{j} + 300\mathbf{k}$
 15 $\mathbf{X} = \mathbf{i} + 4\mathbf{j} + 3\mathbf{k} + t\mathbf{k}$ 17 $\mathbf{A} \perp \mathbf{B}$ 19 -20 21 $-\mathbf{i} + 3\mathbf{j} - \mathbf{k}$

23

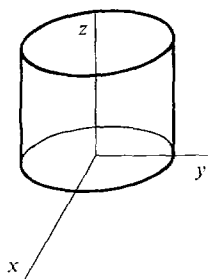


- 25 $-x - y + 2z = 0$ 27 $(-1, -2, 4)$
 29 $\mathbf{S} = \sin t \cos t \mathbf{i} + \sin^2 t \mathbf{j} + \cos t \mathbf{k}$, $\mathbf{S} = -\sin t \cos t \mathbf{i} - \sin^2 t \mathbf{j} + \cos t \mathbf{k}$
 31 $\mathbf{V} = \cos(2t)\mathbf{i} + \sin(2t)\mathbf{j} - \sin t \mathbf{k}$ or $\mathbf{V} = -\cos(2t)\mathbf{i} - \sin(2t)\mathbf{j} - \sin t \mathbf{k}$, $|\mathbf{V}| = \sqrt{1 + \sin^2 t}$,
 $\mathbf{A} = -2 \sin(2t)\mathbf{i} + 2 \cos(2t)\mathbf{j} - \cos t \mathbf{k}$ or $\mathbf{A} = 2 \sin(2t)\mathbf{i} - 2 \cos(2t)\mathbf{j} - \cos t \mathbf{k}$
 33 $\mathbf{i} + \frac{1}{2}\mathbf{j} + \frac{1}{3}\mathbf{k} + t(-\mathbf{i} - \frac{1}{2}\mathbf{j} - \frac{1}{3}\mathbf{k})$
 35 $\mathbf{S} = (-\cos e^t + \cos 1)\mathbf{i} + (\sin e^t - \sin 1)\mathbf{j} + (e^t - 1)\mathbf{k}$

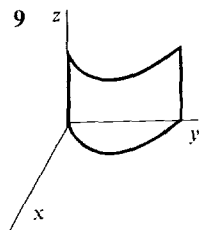
Section 11.1



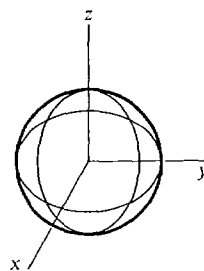
7



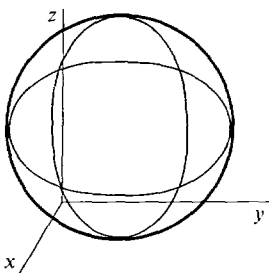
9



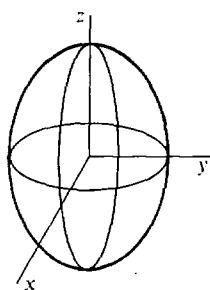
11



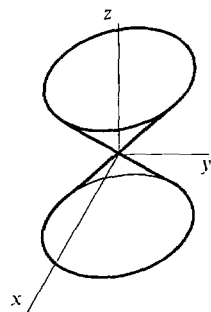
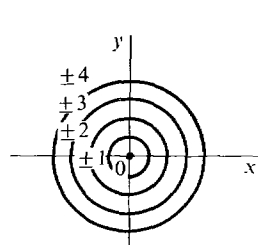
13



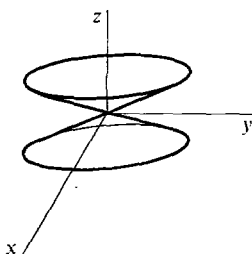
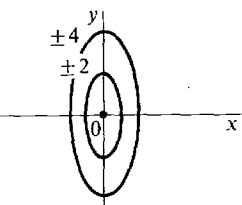
15



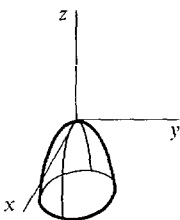
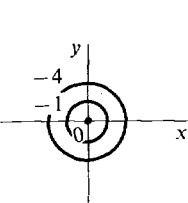
17



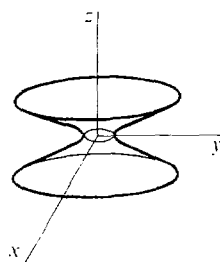
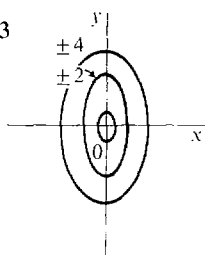
19



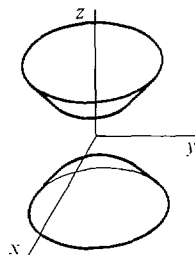
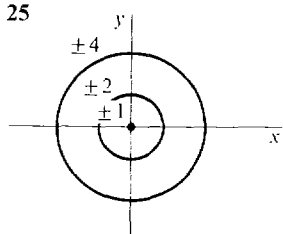
21



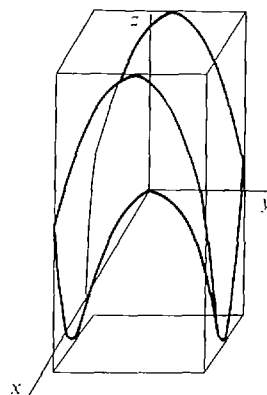
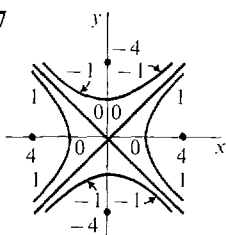
23



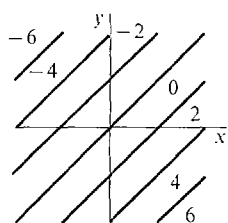
25



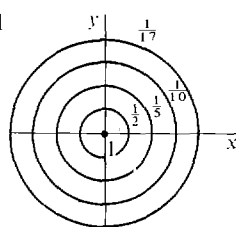
27



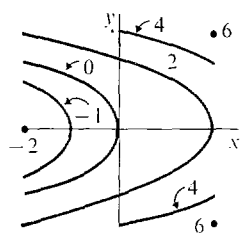
29



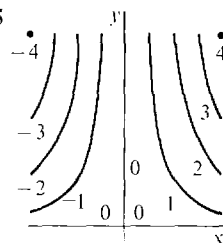
31

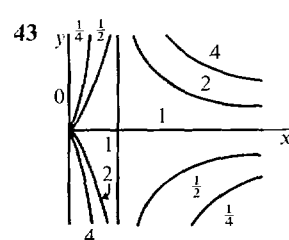
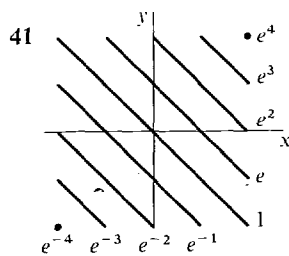
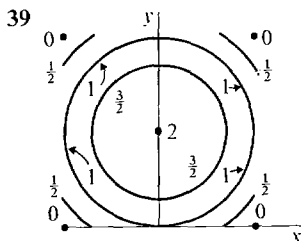
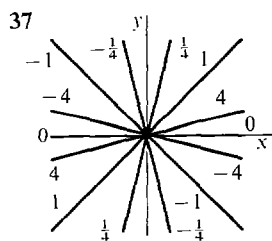


33



35





Section 11.2

- 1 all (x, y) 3 all (x, y) 5 $y \neq -x$ 7 $y \neq -2$ 9 $x \neq 2$ and $y \neq -1$
 11 $x + y > 0$ 13 $x > y$ 15 $x > 0$ 17 $x^2 > y$ 19 $x > 0$ and $y > 0$
 21 $x^2 > y$ 23 $x > 0$ and $y > 0$ and $x \neq 1/y$ 25 $x > 0$ and $y > 0$
 27 $x \neq 4y$ and $y^2 > x$ 29 $\cos x + y > 0$ 31 $x \neq y$ 33 $x > y$ and $y \neq z$
 35 $(x, y, z) \neq (0, 0, 0)$ 37 $x + y > 0$ and $z \neq 0$ 43 e 45 ∞

Section 11.3

- 1 $\partial z/\partial x = 4, \partial z/\partial y = -3$ 3 $\partial z/\partial x = y^2 + 3x^2y, \partial z/\partial y = 2xy + x^3$
 5 $\frac{\partial z}{\partial x} = -\frac{2x}{(x^2 + y^2)^2}, \frac{\partial z}{\partial y} = -\frac{2y}{(x^2 + y^2)^2}$ 7 $f_x(x, y) = y, f_y(x, y) = x$
 9 $f_x(x, y) = a, f_y(x, y) = b$ 11 $f_x(x, y) = 2xe^{x^2-y^2}, f_y(x, y) = -2ye^{x^2-y^2}$
 13 $f_x(x, y) = \frac{1}{2\sqrt{x+2y}}, f_y(x, y) = \frac{1}{\sqrt{x+2y}}$ 15 $\partial z/\partial x = yx^{y-1}, \partial z/\partial y = x^y \ln x$
 17 $\partial z/\partial x = 1/x, \partial z/\partial y = 1/y$
 19 $\frac{\partial z}{\partial x} = -\frac{\ln y}{x(\ln x)^2}, \frac{\partial z}{\partial y} = \frac{1}{y \ln x}$ 21 $\frac{\partial z}{\partial x} = \frac{2xy}{\sqrt{1-x^4y^2}}, \frac{\partial z}{\partial y} = \frac{x^2}{\sqrt{1-x^4y^2}}$
 23 $\frac{\partial w}{\partial x} = \frac{x}{\sqrt{x^2 + y^2 + z^2}}, \frac{\partial w}{\partial y} = \frac{y}{\sqrt{x^2 + y^2 + z^2}}, \frac{\partial w}{\partial z} = \frac{z}{\sqrt{x^2 + y^2 + z^2}}$
 25 $f_x(x, y, z) = a, f_y(x, y, z) = b, f_z(x, y, z) = c$
 27 $\partial w/\partial x = -z \sin x, \partial w/\partial y = z \cos y, \partial w/\partial z = \cos x + \sin y$ 29 $f_x(1, 2) = 4, f_y(1, 2) = 4$
 31 $f_x(-1, 1) = -1, f_y(-1, 1) = 1$ 33 $\frac{\partial z}{\partial x}(0, 2) = 2, \frac{\partial z}{\partial y}(0, 2) = 0$
 35 $\frac{\partial z}{\partial x}(1, 0) = e, \frac{\partial z}{\partial y}(1, 0) = 0$ 37 $\frac{\partial z}{\partial x}(2, 3) = -\frac{4}{961}, \frac{\partial z}{\partial y}(2, 3) = -\frac{27}{961}$
 39 $f_x(1, 2, 3) = 2, f_y(1, 2, 3) = 4, f_z(1, 2, 3) = 6$ 41 $1/\sqrt{5}$ 43 $1/3$ 45 $b = 2, c = 1$
 47 $C_x(x, y) = 3 - \frac{1}{2}\sqrt{y/x}, C_y(x, y) = 4 - \frac{1}{2}\sqrt{x/y}$

Section 11.4

- 1 $\Delta z = 3 \Delta x - 2 \Delta y, dz = 3 dx - 2 dy$
 3 $\Delta z = 2xy^2 \Delta x + 2x^2y \Delta y + y^2 \Delta x^2 + 4xy \Delta x \Delta y + x^2 \Delta y^2 + 2x \Delta x \Delta y^2 + 2y \Delta x^2 \Delta y + \Delta x^2 \Delta y^2, dz = 2xy^2 dx + 2x^2y dy$
 5 $\Delta z = -\frac{x \Delta y + y \Delta x + \Delta x \Delta y}{(x + \Delta x)(y + \Delta y)xy}, dz = -\frac{dx}{x^2y} - \frac{dy}{xy^2}$
 7 $\Delta z = e^{3x-4y}(e^{3\Delta x-4\Delta y} - 1), dz = e^{3x-4y}(3 dx - 4 dy)$
 9 $\Delta z = \cos(x + \Delta x) \sin(y + \Delta y) - \cos x \sin y, dz = -\sin x \sin y dx + \cos x \cos y dy$
 11 $\Delta z = x \ln(1 + (\Delta y/y)) + \Delta x \ln(y + \Delta y), dz = \ln y dx + (x/y) dy$
 13 $\Delta w = \Delta x + 2 \Delta y + 3 \Delta z, dw = dx + 2 dy + 3 dz$
 15 $\Delta w = y \Delta x + (x + z) \Delta y + y \Delta z + \Delta x \Delta y + \Delta y \Delta z, dw = y dx + (x + z) dy + y dz$
 17 $\Delta z = dz + \Delta x \Delta x + \Delta y \Delta y$ 19 $\Delta z = dz + (y \Delta x + 2x \Delta y + \Delta x \Delta y) \Delta x + 0 \Delta y$
 21 $\Delta z = dz + \frac{\Delta y}{y(y + \Delta y)} \Delta x + \frac{x \Delta y}{y^2(y + \Delta y)} \Delta y$ 23 $z = 4x + 4y - 6$
 25 $z = 4x + 4y - 2$ 27 $z = \frac{1}{2}x + \frac{1}{2}y + 1$ 29 $z = 6e^3x + e^3y - 8e^3$
 31 $z = \frac{\sqrt{2}}{4}x + \frac{\sqrt{6}}{4}y + \frac{\sqrt{6}}{4} - \pi\left(\frac{\sqrt{2}}{12} + \frac{\sqrt{6}}{16}\right)$ 33 $z = x - 2$ 35 $z = 1$
 37 $x - 2y + 2z = 9$ 39 $x + y - z = 1$

Section 11.5

- 1 $2e^{2t} + 2e^{-2t}$ 3 $-\frac{\cos(t/a) + \cos(t/b)}{[a \sin(t/a) + b \sin(t/b)]^2}$ 5 $\frac{2y}{x \ln y} - \frac{2x \ln x}{y(\ln y)^2}$
 7 $(t+1)^{1/t} \left[\frac{1}{t(t+1)} - \frac{\ln(t+1)}{t^2} \right]$ 9 $(\sin t)^{\cos t} \left[\frac{\cos^2 t}{\sin t} - \sin t \ln(\sin t) \right]$
 11 $\frac{2t}{(t^2-1)\ln(t^2+1)} - \frac{2t \ln(t^2-1)}{(t^2+1)[\ln(t^2+1)]^2}$ 13 $3\sqrt{1-t^4} - 2\sqrt{1-t^3}$
 15 $\frac{\partial z}{\partial s} = 3s^2 \cos^3 t, \frac{\partial z}{\partial t} = -3s^2 \sin t \cos^2 t$ 17 $\frac{\partial z}{\partial s} = \frac{2s}{s^2-t^2}, \frac{\partial z}{\partial t} = -\frac{2t}{s^2-t^2}$
 19 $\frac{\partial z}{\partial s} = -\frac{a}{(s+t)^2} - \frac{b}{(s-t)^2}, \frac{\partial z}{\partial t} = -\frac{a}{(s+t)^2} + \frac{b}{(s-t)^2}$ 21 $b \frac{\partial z}{\partial x} = abf'(ax+by) = a \frac{\partial z}{\partial y}$
 25 $\frac{dw}{dt} = e^t \cos(\sqrt{t}) - e^{-t} \sin(\sqrt{t}) + \frac{1}{2\sqrt{t}}(-e^t \sin(\sqrt{t}) + e^{-t} \cos(\sqrt{t}))$
 27 $\frac{dz}{dt} = \frac{x(dx/dt) + y(dy/dt)}{\sqrt{x^2 + y^2}}$ or $\frac{dz}{dt} = \frac{x}{z} \frac{dx}{dt} + \frac{y}{z} \frac{dy}{dt}$
 29 $\frac{dz}{dt} = x^y \left(\frac{y}{x} \frac{dx}{dt} + \ln x \frac{dy}{dt} \right)$ or $\frac{dz}{dt} = \frac{zy}{x} \frac{dx}{dt} + z \ln x \frac{dy}{dt}$
 31 $\frac{\partial z}{\partial s} = af'(u), \frac{\partial z}{\partial t} = bf'(u)$ 33 $\frac{\partial z}{\partial s} = z \frac{\partial u}{\partial s}, \frac{\partial z}{\partial t} = z \frac{\partial u}{\partial t}$
 35 $\frac{\partial z}{\partial s} = g'(s)h(t), \frac{\partial z}{\partial t} = g(s)h'(t)$ 37 -2 39 -3 41 2 43 $1/25$

Section 11.6

- 1 $\frac{\partial z}{\partial x} = 3, \frac{dz}{dx} = 3 - 4e^x$ 3 $\frac{\partial z}{\partial x} = -\sin x, \frac{dz}{dx} = -\sin x + 3 \cos(3x)$
 5 $\frac{\partial z}{\partial x} = yx^{y-1}, \frac{dz}{dx} = x^y(1 + \ln x)$ 7 $\frac{\partial z}{\partial x} = \frac{y}{1+x^2y^2}, \frac{dz}{dx} = \frac{e^{-x}(1-x)}{1+x^2e^{-2x}}$ 9 $\frac{y+x}{y-x}$
 11 $-\frac{2x+2y^3}{6xy^2+1}$ 13 $-\frac{1+y \cos(xy)}{x \cos(xy)}$ 15 slope $= -\frac{3}{4}, 4y = -3x + 14$
 17 slope $= 5, y = 5x - 6$ 19 slope $= -1, y = -x + 2$ 21 slope $= 1, y = x$
 23 $\frac{\partial w}{\partial x}(x, y) = 15, \frac{\partial w}{\partial y}(x, y) = -34$

$$\begin{aligned}
 25 \quad \frac{\partial w}{\partial x}(x, y) &= \frac{10x - 6y}{\sqrt{10x^2 - 12xy + 5y^2}}, \quad \frac{\partial w}{\partial y}(x, y) = \frac{-6x + 5y}{\sqrt{10x^2 - 12xy + 5y^2}} \\
 27 \quad 6x - 5y + 4z &= -21 \quad 29 \quad x + y + z = 3 \quad 31 \quad x + y + z = 0 \\
 33 \quad \frac{\partial z}{\partial x} &= -\frac{xy}{z}, \quad \frac{\partial z}{\partial y} = -\frac{x^2}{2z} \quad 35 \quad \frac{\partial z}{\partial x} = \frac{\cos(xy)}{\sin(yz)}, \quad \frac{\partial z}{\partial y} = \frac{x \cos(xy) - z \sin(yz)}{y \sin(yz)} \\
 37 \quad \frac{\partial z}{\partial x} &= -\frac{z}{3x}, \quad \frac{\partial z}{\partial y} = -\frac{2z}{3y} \quad 39 \quad \frac{dz}{dx} = y - \frac{x}{1 + \sqrt{x}} \\
 41 \quad \frac{dw}{dx} &= \frac{\partial w}{\partial x} + \frac{\partial w}{\partial y} \frac{dy}{dx} + \frac{\partial w}{\partial z} \frac{dz}{dx}
 \end{aligned}$$

Section 11.7

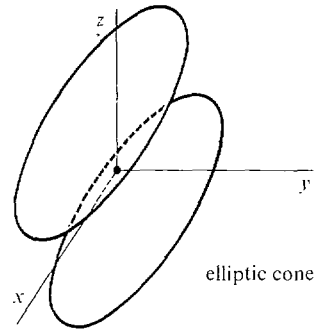
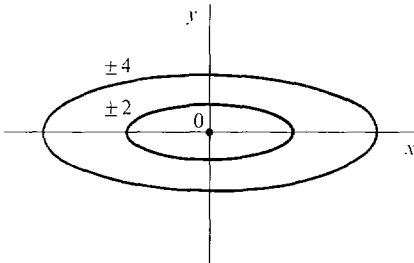
- 1 max = 3 at $(-1, -1)$ and $(1, 1)$; min = 0 at $(0, 0)$
 3 max = 48 at $(3, 3)$; min = -6 at $(1, -2)$ 5 max = 4 at $(2, 1)$; min = -5 at $(2, 4)$
 7 max = 2 at $(\pi/2, \pi/2)$; min = 0 at $(0, 0), (0, \pi), (\pi, 0), (\pi, \pi)$
 9 max = 1 at $(-1, 1)$ and $(1, 1)$; min = $-\frac{1}{4}$ at $(0, \frac{1}{2})$
 11 max = $\frac{1}{4}$ at $(\frac{1}{2}, 0, \frac{1}{2})$ and $(\frac{1}{2}, 1, -\frac{1}{2})$; min = $-\frac{1}{4}$ at $(0, \frac{1}{2}, \frac{1}{2})$ and $(1, \frac{1}{2}, -\frac{1}{2})$
 13 max = $1 + \sqrt{2}$ at $(\sqrt{2}/2, \sqrt{2}/2, 1)$; min = $-\frac{1}{2}$ at $(-\frac{1}{2}, -\frac{1}{2}, \frac{1}{2})$
 15 max = 3 at $(-1, -1, 1), (-1, 1, 1), (1, -1, 1), (1, 1, 1)$; min = 0 at $(0, 0, 0)$
 17 no max; min = -4 at $(-2, 0)$ 19 no max; no min
 21 no max; min = 6 at $(\frac{1}{2}, 4)$ 23 max = 1 at $(0, 0)$; no min 25 no max, no min
 27 $x = 4, y = 2, z = 2$ 29 6 in. $\times$ 6 in. $\times$ 12 in. 31 $2\sqrt{3}/3$ 33 $(\frac{5}{3}, \frac{10}{3}, -\frac{5}{3})$
 35 $(1, 1, 1), (1, -1, -1), (-1, 1, -1), (-1, -1, 1)$
 39 $\frac{2}{3}(\frac{2}{3}V)^{1/3}$ in. $\times$ $\frac{2}{3}(\frac{2}{3}V)^{1/3}$ in. $\times$ $(\frac{2}{3}V)^{1/3}$ in. 41 $x = 100, y = 200, P(100, 200) = 50,000$

Section 11.8

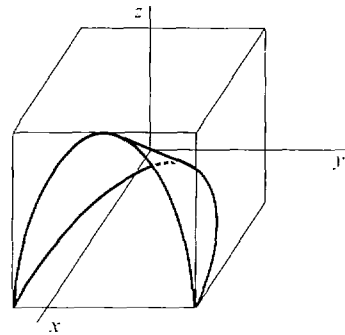
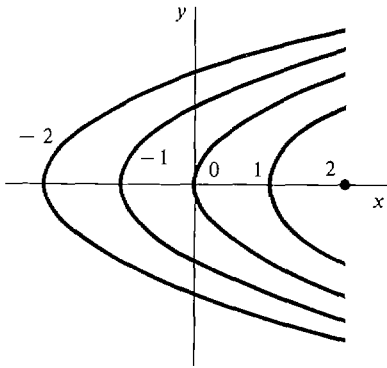
$$\begin{aligned}
 1 \quad \frac{\partial^2 z}{\partial x^2} &= 2, \quad \frac{\partial^2 z}{\partial y^2} = 4, \quad \frac{\partial^2 z}{\partial x \partial y} = 0 \quad 3 \quad \frac{\partial^2 z}{\partial x^2} = 2a, \quad \frac{\partial^2 z}{\partial y^2} = 2c, \quad \frac{\partial^2 z}{\partial x \partial y} = b \\
 5 \quad \frac{\partial^2 z}{\partial x^2} &= e^{x+y}(x+2), \quad \frac{\partial^2 z}{\partial y^2} = xe^{x+y}, \quad \frac{\partial^2 z}{\partial x \partial y} = e^{x+y}(x+1) \\
 7 \quad \frac{\partial^2 z}{\partial x^2} &= -\frac{a^2}{(ax+by)^2}, \quad \frac{\partial^2 z}{\partial y^2} = -\frac{b^2}{(ax+by)^2}, \quad \frac{\partial^2 z}{\partial x \partial y} = -\frac{ab}{(ax+by)^2} \\
 9 \quad \frac{\partial^2 z}{\partial x^2} &= a(a-1)x^{a-2}y^b, \quad \frac{\partial^2 z}{\partial y^2} = b(b-1)x^ay^{b-2}, \quad \frac{\partial^2 z}{\partial x \partial y} = abx^{a-1}y^{b-1} \\
 11 \quad \frac{\partial^2 w}{\partial x^2} &= \frac{\partial^2 w}{\partial y^2} = \frac{\partial^2 w}{\partial z^2} = \frac{\partial^2 w}{\partial x \partial y} = \frac{\partial^2 w}{\partial x \partial z} = \frac{\partial^2 w}{\partial y \partial z} = -\frac{1}{4}(x+y+z)^{-3/2} \\
 13 \quad \frac{\partial^3 z}{\partial x^3} &= 12y^2, \quad \frac{\partial^3 z}{\partial y^3} = -36x^2, \quad \frac{\partial^3 z}{\partial x^2 \partial y} = 24xy - 36y^2, \quad \frac{\partial^3 z}{\partial x \partial y^2} = 12x^2 - 72xy \\
 15 \quad \frac{\partial^3 z}{\partial x^3} &= a^3 e^{ax+by}, \quad \frac{\partial^3 z}{\partial y^3} = b^3 e^{ax+by}, \quad \frac{\partial^3 z}{\partial x^2 \partial y} = a^2 b e^{ax+by}, \quad \frac{\partial^3 z}{\partial x \partial y^2} = ab^2 e^{ax+by} \\
 17 \quad \frac{\partial^2 z}{\partial \theta^2} &= r^2 \sin^2 \theta \frac{\partial^2 f}{\partial x^2} - 2r^2 \sin \theta \frac{\partial^2 f}{\partial x \partial y} + r^2 \cos^2 \theta \frac{\partial^2 f}{\partial y^2} - r \cos \theta \frac{\partial f}{\partial x} - r \sin \theta \frac{\partial f}{\partial y} \\
 19 \quad \frac{\partial^2 z}{\partial x^2} &= a^2 f''(u), \quad \frac{\partial^2 z}{\partial y^2} = b^2 f''(u), \quad \frac{\partial^2 z}{\partial x \partial y} = ab f''(u) \quad 21 \quad \frac{\partial^2 z}{\partial x^2} = g''(x), \quad \frac{\partial^2 z}{\partial y^2} = h''(y), \quad \frac{\partial^2 z}{\partial x \partial y} = 0 \\
 23 \quad \frac{\partial^2 z}{\partial x^2} &= n(n-1)u^{n-2} \left(\frac{\partial u}{\partial x} \right)^2 + nu^{n-1} \frac{\partial^2 u}{\partial x^2}, \quad \frac{\partial^2 z}{\partial y^2} = n(n-1)u^{n-2} \left(\frac{\partial u}{\partial y} \right)^2 + nu^{n-1} \frac{\partial^2 u}{\partial y^2}, \\
 &\quad \frac{\partial^2 z}{\partial x \partial y} = n(n-1)u^{n-2} \left(\frac{\partial u}{\partial x} \right) \left(\frac{\partial u}{\partial y} \right) + nu^{n-1} \frac{\partial^2 u}{\partial x \partial y} \\
 25 \quad \frac{\partial^2 z}{\partial s^2} &= a \frac{\partial^2 x}{\partial s^2} + b \frac{\partial^2 y}{\partial s^2}, \quad \frac{\partial^2 z}{\partial t^2} = a \frac{\partial^2 x}{\partial t^2} + b \frac{\partial^2 y}{\partial t^2}, \quad \frac{\partial^2 z}{\partial s \partial t} = a \frac{\partial^2 x}{\partial s \partial t} + b \frac{\partial^2 y}{\partial s \partial t} \\
 27 \quad \frac{\partial^2 z}{\partial s^2} &= f'(x)[(g'(s))^2 + g'(s)g''(s)], \quad \frac{\partial^2 z}{\partial t^2} = f'(x)[(h'(t))^2 + h'(t)h''(t)], \quad \frac{\partial^2 z}{\partial s \partial t} = f'(x)g'(s)h'(t)
 \end{aligned}$$

Extra Problems for Chapter 11

1



3



- 5 $x \neq 0$ 7 $1/x + 1/y > 0$ 9 $f_x(x, y) = a, f_y(x, y) = b$
 11 $\frac{\partial z}{\partial x} = \frac{1}{x \ln y}, \frac{\partial z}{\partial y} = -\frac{\ln x}{y(\ln y)^2}$ 13 $\Delta z = -\frac{\Delta x}{x(x + \Delta x)} - \frac{2 \Delta y}{y(y + \Delta y)}, dz = -\frac{dx}{x^2} - \frac{2 dy}{y^2}$
 15 $-8y + z = 4$ 17 $\frac{dz}{dt} = -\frac{2 \log_{(2t+1)}(3t+2)}{(2t+1) \ln(2t+1)} + \frac{3}{(3t+2) \ln(2t+1)}$ 19 1
 21 $y = -8x + 17$, slope = -8 23 max = 4 at (0, 0) and (3, 3); min = -1 at (1, 2)
 25 no max; no min 27 $\frac{\partial^2 z}{\partial x^2} = -\frac{2xy^3}{(1+x^2y^2)^2}, \frac{\partial^2 z}{\partial y^2} = -\frac{2x^3y}{(1+x^2y^2)^2}, \frac{\partial^2 z}{\partial x \partial y} = -\frac{1-x^2y^2}{(1+x^2y^2)^2}$
 29 $\frac{\partial^2 z}{\partial t^2} = \cosh^2 \theta \frac{\partial^2 f}{\partial x^2} + 2 \sinh \theta \cosh \theta \frac{\partial^2 f}{\partial x \partial y} + \sinh^2 \theta \frac{\partial^2 f}{\partial y^2}$

Section 12.1

- 1 $168/64 = 2.625$ 3 44 5 1.025 7 $(\pi/6)^2(7 + 4\sqrt{3}) \sim 3.8$
 9 $e^{-5} + e^{-4} + 2e^{-3} + 2e^{-2} + 2e^{-1} + 2 + 2e + 2e^2 + e^3 + e^4 \sim 97.52$
 11 $150/64 \sim 2.34$ 13 $((11 + 7\sqrt{2})\pi)/32 \sim 2.05$ 15 108

Section 12.2

- 1 $7/2 = 3.5$ 3 $128/3 = 42\frac{2}{3}$ 5 $\frac{3}{2} \ln 2 \sim 1.04$ 7 4
 9 $\frac{1}{2}(e^6 - e^2 - e^{-2} + e^{-6}) \sim 197.9$ 11 $13/6 \sim 2.17$ 13 $32/15 \sim 2.13$
 15 $36\pi \sim 113.1$ 17 $14/3$ 19 30 21 2 23 $\frac{4}{15}(212 - 36\sqrt{6})$ 25 $e - 1$
 27 $8/3$ 29 $3^8/40$
 31 $0 \leq x \leq 5, 0 \leq y \leq 5 - x$, or $0 \leq y \leq 5, 0 \leq x \leq 5 - y$; $\int_0^5 \int_0^{5-x} f(x, y) dy dx$, or $\int_0^5 \int_0^{5-y} f(x, y) dx dy$

- 33 $-2 \leq x \leq 2, -\sqrt{4-x^2} \leq y \leq \sqrt{4-x^2}, \int_{-2}^2 \int_{-\sqrt{4-x^2}}^{\sqrt{4-x^2}} f(x, y) dy dx$
 35 $-4 \leq x \leq 1, 3x \leq y \leq 4-x^2, \int_{-4}^1 \int_{3x}^{4-x^2} f(x, y) dy dx$
 37 $-1 \leq y \leq 1, 1/2 \leq x \leq 1/(1+y^2), \int_{-1}^1 \int_{1/2}^{1/(1+y^2)} f(x, y) dx dy$ 39 $\pi/4$ 41 $32/3$
 43 $\frac{1}{2}\pi ab$

Section 12.3

- 1 $3/4$ 3 1 5 $4/3$ 7 $16/15$ 9 $8/3$ 11 8π 13 $8/15$ 15 144
 17 $\frac{4}{3}\pi abc$

Section 12.4

- 1 (a) $4abk$ (b) $(0, 0)$ (c) $\frac{4}{3}(ba^3 + ab^3)k$ 3 (a) $\frac{2}{3}k$ (b) $(\frac{3}{8}, \frac{3}{8})$ (c) $\frac{44}{105}k$
 5 (a) $26/3$ (b) $(19/13, 151/65)$ (c) $944/15$
 7 (a) $\frac{2}{7} + \frac{1}{6}$ (b) $\left(\frac{\frac{2}{9} + \frac{2}{15}}{\frac{2}{7} + \frac{1}{6}}, \frac{\frac{1}{11} + \frac{1}{15}}{\frac{2}{7} + \frac{1}{6}}\right)$ (c) $\frac{2}{11} + \frac{1}{9} + \frac{2}{45} + \frac{1}{28}$
 9 (a) $e^2 + e^{-2} - 2$ (b) $\left(\frac{e^2 + 3e^{-2} - 2}{e^2 + e^{-2} - 2}, \frac{e^4 + e^{-4} - 2}{4(e^2 + e^{-2} - 2)}\right)$
 (c) $\frac{1}{9}e^6 + 2e^2 - \frac{2}{9} - 10e^{-2} + \frac{1}{9}e^{-6}$ 11 2 13 (a) $(\sqrt{2}/48)g$ (b) $g/24$
 15 $m = \frac{8}{3}, W = \frac{16}{15}g$

Section 12.5

- 1 6π 3 8π 5 $\frac{81}{2}\pi$ 7 $2\pi(1 - \ln 2)$ 9 $4/21$ 11 $\pi/48$
 13 $32/9$ 15 $8\pi^8 + \frac{64}{15}\pi^5$ 17 $5\pi/3$ 19 $\pi/3 - 4/9$ 21 $\frac{1}{3}(\beta - \alpha)(b^3 - a^3)$
 23 (a) $\pi b^3/3$ (b) $\pi b^5/10$ 25 $(\pi k/2)(b^4 - a^4)$ 27 (a) $\bar{x} = 4/(3\pi), \bar{y} = 4/(3\pi)$ (b) $\pi k/8$
 29 (a) $\bar{x} = 0, \bar{y} = \frac{3\sqrt{3} + 8\pi}{6\sqrt{3} + 4\pi}b$ (b) $\left(\frac{5}{6}\pi + \frac{7\sqrt{3}}{8}\right)b^4k$ 31 (a) π (c) $\sqrt{\pi}$

Section 12.6

- 1 12 3 12 5 $13/56$ 7 $16/27$ 9 40
 11 $\frac{763}{594} \times 10^9 = \left(\frac{4}{27} + \frac{100}{88}\right) \times 10^9 \sim 1.3 \times 10^9$
 13 $\frac{e^6}{24} - \frac{e^4}{15} + \frac{e^{-2}}{24} - \frac{e^{-6}}{60}$ 15 $\frac{52}{63} - \frac{12\sqrt{3}}{35}$
 17 (a) 3 (b) $(\frac{19}{36}, \frac{5}{9}, \frac{7}{12})$ (c) $I_z = \frac{9}{4}, I_y = \frac{7}{3}, I_x = \frac{29}{12}$
 19 (a) 1 (b) $(\frac{3}{4}, \frac{5}{12}, \frac{7}{12})$ (c) $I_z = \frac{5}{6}, I_y = \frac{11}{10}, I_x = \frac{11}{15}$
 21 (a) $\frac{5}{18}$ (b) $(\frac{3}{20}, \frac{3}{20}, \frac{65}{972})$ (c) $I_z = \frac{5}{16}, I_y = \frac{73}{960}, I_x = \frac{73}{960}$
 23 (a) $\frac{1}{6}abck$ (b) $\left(\frac{a}{4}, \frac{b}{4}, \frac{c}{4}\right)$ (c) $I_z = \frac{abck}{60}(a^2 + b^2), I_y = \frac{abck}{60}(a^2 + c^2), I_x = \frac{abck}{60}(b^2 + c^2)$
 25 (a) $abck$ (b) $\left(\frac{a}{2}, \frac{b}{2}, \frac{c}{2}\right)$ (c) $I_z = \frac{abck}{3}(a^2 + b^2), I_y = \frac{abck}{3}(a^2 + c^2), I_x = \frac{abck}{3}(b^2 + c^2)$

Section 12.7

- 1 $\frac{4\pi}{3}$ 3 $\frac{\pi}{10}$ 5 $\frac{128}{7}$ 7 $\frac{2\pi hb^3}{3}$ 9 $\frac{\pi hb^4}{10}$ 11 $\left(0, 0, \frac{2}{3}\right)$
 13 $\frac{b^4ck\pi}{2} + \frac{2b^2c^3k\pi}{3}$ 15 $\frac{\pi hb^4k}{10}$ 17 $\frac{4\pi b^5}{5}$ 19 $\frac{4\pi}{15}$ 21 $\frac{4\pi b^4}{3}$
 23 $\frac{\pi b^5}{10}(1 - \cos(2\alpha))$ or $\frac{\pi b^5}{5}\sin^2 \alpha$ 25 $\frac{4}{3}\pi(b^3 - a^3)$ 27 $\frac{\pi b^3}{6}(1 - \cos^4 \beta)$ 29 πc^4
 31 $\frac{8\pi kb^5}{15}$ 33 $b^3\left(\frac{2\pi}{3} - \frac{8}{9}\right)$ 35 $\frac{3}{8}b$ from the center

Extra Problems for Chapter 12

- 1 0 3 0 5 $1/3$ 7 $4/5$ 9 $\frac{1}{2}(\ln 2)^2 - \frac{1}{6}(\ln 2)^3$ 11 $1/6$
 13 $m = 2k$, $(\bar{x}, \bar{y}) = (\pi/2, \pi/8)$, $I_0 = (\pi^2 - \frac{32}{9})k$ 15 $m = \pi r^4/4$, $(\bar{x}, \bar{y}) = (0, 0)$, $I_0 = \pi r^6/6$
 17 45π 19 $2\pi a$ 23 $311/3960$
 25 $(\bar{x}, \bar{y}, \bar{z}) = (\frac{1}{5}, \frac{1}{5}, \frac{1}{30})$, $I_z = \frac{k}{60}$, $I_y = I_x = \frac{29k}{3360}$
 27 $(\bar{x}, \bar{y}, \bar{z}) = (0, 0, \frac{b^2 + c}{2})$, $I_z = \frac{\pi b^4 c k}{2}$ 29 $m = \pi(b^4 - a^4)$, $I = \frac{4\pi}{9}(b^6 - a^6)$

Section 13.1

- 1 $\text{grad } f = 2xi + 2yj$, $f_U = \sqrt{2}x + \sqrt{2}y$ 3 $\text{grad } f = 2xy^3i + 3x^2y^2j$, $f_U = \frac{6}{5}xy^3 - \frac{1}{5}x^2y^2$
 5 $\text{grad } f = -\sin x \sin yi + \cos x \cos yj$, $f_U = (1/\sqrt{5})(-\sin x \sin y + 2 \cos x \cos y)$
 7 $\text{grad } f = \frac{x}{\sqrt{x^2 + y^2}}i + \frac{y}{\sqrt{x^2 + y^2}}j$, $f_U = \frac{x - y}{\sqrt{2x^2 + 2y^2}}$
 9 $\text{grad } f = yzi + xzj + xyk$, $f_U = \frac{1}{3}(yz + 2xz - 2xy)$
 11 $\text{grad } f = -x^{-2}i - 2y^{-2}j - 3z^{-2}k$, $f_U = (1/\sqrt{2})(-x^{-2} + 3z^{-2})$
 13 $\text{grad } f = \frac{xi + yj + zk}{\sqrt{x^2 + y^2 + z^2}}$, $f_U = \frac{x \cos \alpha + y \cos \beta + z \cos \gamma}{\sqrt{x^2 + y^2 + z^2}}$ 15 $7\sqrt{10}/20$
 17 $9a/\sqrt{a^2 + b^2}$ 19 $-1/\sqrt{3}$ 21 $(1/\sqrt{2})(i + j)$ 23 $\frac{1}{2}(3i + 6j + 2k)$
 25 $(f_U)_V = \frac{\partial^2 z}{\partial x^2}u_1v_1 + \frac{\partial^2 z}{\partial x \partial y}(u_1v_2 + u_2v_1) + \frac{\partial^2 z}{\partial y^2}u_2v_2$

Section 13.2

- 1 $2e^3$ 3 $\frac{9}{2}e - \frac{3}{2}$ 5 $\sin 1 - \cos 1 + 1$ 7 $\frac{3}{20} + \frac{5}{7} \ln 4$ 9 $-2\pi, 2\pi$
 11 -4π 13 $\frac{11}{30}$ 15 $\frac{1}{2}$ 17 $\frac{1}{2} \ln(\frac{29}{2})$ 19 $1243/3$

Section 13.3

- 1 no potential function 3 no potential function 5 no potential function
 7 $y \sin x + C$ 9 $-2x + 6y + C$ 11 no potential function
 13 $\frac{3}{2}x^2 + 5xy - y^2 + C$ 15 $\cosh x \cosh y + C$ 23 $\frac{3}{2}x^2 + 4xy - y^2 = C$
 25 $\frac{2}{3}x^{3/2} + x\sqrt{y} = C$ 27 $\frac{1}{3}y^3 + y \arctan x = C$ 29 $\cos x \sin y = C$
 31 $(x^2/2) + (y^2/2) + (2/3)(x + y)^{3/2} = C$ 33 $P(x, y) = 2 \sin x \cos x \sin y$

Section 13.4

- 1 1 3 $\frac{1}{2}(-e^7 + e^{-1} + e - e^{-7})$ 5 $-\frac{1}{6}$ 7 $\frac{1}{2} - \ln 2$ 9 $-17/12$
 11 $-\pi/2$ 13 (a) $-x - y$ (b) -1 (c) $y - x$ (d) 0
 15 (a) $2bx - 2ay$ (b) $(2b - a)/3$ (c) 0 (d) 0 17 (a) -2 (b) -2π (c) 0 (d) 0
 19 $\pi a^2 + \pi/2$

Section 13.5

- 1 $25\sqrt{21}/4$ 3 $(\pi/6)(5\sqrt{5} - 1)$ 5 $\pi a^2/2$ 7 $(\pi/6)[(1 + 4a^2)^{3/2} - 1]$
 9 $a^2(\pi - 2)$ 11 $A\sqrt{1 + a^2 + b^2}$ 13 $8a^2$ 15 16 17 $-\pi$ 19 $-2e^{-1}$

Section 13.6

- 1 $\text{curl } F = 0$, $\text{div } F = 2x + 2y + 2z$ 3 $\text{curl } F = -i + j - k$, $\text{div } F = 3$
 5 $\text{curl } F = (ze^{x+y} - ye^{x+z})i + (xe^{y+z} - ze^{x+y})j + (ye^{x+z} - xe^{y+z})k$,
 $\text{div } F = e^{y+z} + e^{x+z} + e^{x+y}$ 9 0 11 $A(p(c - b) + q(a - c) + (a - b))$
 13 $abc(a + b + c)$ 15 3 17 $\pi/3$ 19 $\pi/2$

Extra Problems for Chapter 13

- 1 $-\sin x \cos \alpha + \cos y \sin \alpha$ 3 $\text{grad } f = ye^{xy}\mathbf{i} + xe^{xy}\mathbf{j}, f_U = e^{xy}(y \cos \alpha + x \sin \alpha)$
 5 $\frac{1}{\sqrt{14}}(-2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ 7 $\ln\left(\frac{6\sqrt{2}}{5}\right)$ 9 0 11 $x \ln x + xy \ln y - x$
 13 $\frac{3}{2}y^2 - e^{-y} \cos x = C$ 15 $\frac{131}{60}$ 17 $\frac{\sqrt{6}}{2} - \frac{\sqrt{2}}{6}$ 19 2π
 21 $\text{curl } \mathbf{F} = (x^2z - 3xy^2z^2)\mathbf{i} + (xy - 2xyz)\mathbf{j} + (y^2z^3 - xz)\mathbf{k}, \text{div } \mathbf{F} = yz + 2xyz^3 + x^2y$

Section 14.1

- 1 $y = -1/2 \cos(t^2) + C$ 3 $y = \ln(t + C)$ 5 $y = \frac{1 + Ce^{2t}}{1 - Ce^{2t}}, y = 1, y = -1$
 7 $y = -\frac{1}{0.5t^2 + C}, y = 0$ 9 $y = \tan(e^t + C)$ 11 $y = C \sec t, y = 0$
 13 $y = \left(\frac{t^2}{4} + 9\right)^{1/2}$ 15 $y = -\sqrt{2(t \ln t - t) + 6}$ 17 $y = 2$

Section 14.2

- 1 $y = C \cdot e^{-5t}$ 3 $y = C \cdot e^{\arctan t}$ 5 $y = 4 \cdot e^{-t}$ 7 $y = e \cdot e^{\cos t}$ 9 $y = 0$
 11 $y = 4t^2$ 13 $y = e^{1-t^2}$ 15 $y = 100 \cdot e^{-t \cdot \ln 5}$ 17 $y = 1,000,000 \cdot e^{t \cdot \ln 1.5}$

Section 14.3

- 1 $y = 2 + Ce^{-4t}$ 3 $y = 5 + Ce^{-(1/2)t^2}$ 5 $y = -(t^2 + 2t + 2) \cdot Ce^{-4t}$
 7 $y = \frac{1}{3}t^{-1} + Ct^2$ 9 $y = \sin t + C \cos t$ 11 $y = e^{-\cos t} \left(\int_0^t s e^{\cos s} ds + C \right)$
 13 $y = e^{-\int_0^t \cos(e^r) dr} \left[\int_0^t e^{\int_0^s \cos(e^r) dr} ds + C \right]$
 15 $-[400,000t + 15,840,000] + 15,940,000e^{0.025t}$
 17 $15,000e - 25,000$ dollars, or \$15,774.23

Section 14.4

- | | t | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
|---|--------|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | $Y(t)$ | 1.0 | 1.0 | 1.01 | 1.030 | 1.059 | 1.097 | 1.142 | 1.195 | 1.253 | 1.317 | 1.386 |
| 3 | $Y(t)$ | 1.0 | 1.054 | 1.095 | 1.122 | 1.137 | 1.140 | 1.133 | 1.117 | 1.093 | 1.061 | 1.023 |
- 5 Apply the lemma with $M = 4$. 7 Apply the lemma with $M = \pi/2$.
 9 $y(t) = 0$ for $0 \leq t \leq b$, $y(t) = [(2/3)(t - b)]^{3/2}$ for $b < t < \infty$.

Section 14.5

- 1 $10 - i2$ 3 $i10$ 5 $0.1 - i(0.7)$ 7 4 9 $\pm i5$ 11 $-1 \pm i2$
 13 $5 \text{ cis}(\pi/2)$ 15 $3\sqrt{2} \text{ cis}(-3\pi/4)$ 17 $2 \text{ cis}(-\pi/6)$ 19 $-i2/3$
 21 $2 \text{ cis}(-\pi/12)$ 23 $-4 + i4$ 25 $\pm 2^{1/4} \text{ cis}(\pi/8)$ 27 $\pm 2 \text{ cis}(-\pi/4)$,
 or $\pm \sqrt{2}(1 - i)$ 29 ie^{-3} 31 $e\sqrt{2}/2 - ie\sqrt{2}/2$ 33 $(5 - i3)e^{(5-i3)t}$
 35 $(3 + i2)e^{(2-i7)+(3+i2)t}$ 37 $Ce^{(-2+i3)t}$ 39 $Ce^{(3-i5)t}$
 41 $e^{i+(2-i)t}$, or $e^{2t} \text{ cis}(1 - t)$ 43 $4e^{(2-i)t}$, or $4e^{2t} \text{ cis}(-t)$

Section 14.6

- 1 $Ae^{2t} + Be^{-3t}$ 3 $Ae^{5t} + Bte^{5t}$ 5 $A \cos(4t) + B \sin(4t)$
 7 $e^t[A \cos t + B \sin t]$ 9 $-\frac{1}{4}e^{-5t} + \frac{5}{4}e^{-t}$ 11 $5e^{-6t} + 20te^{-6t}$
 13 $-2 \cos(\sqrt{5}t) + \sqrt{5} \sin(\sqrt{5}t)$ 15 $e^{-6t}[4 \cos t + 24 \sin t]$
 17 $2 \cos(2t - \pi/6)$, amplitude = 2, frequency = 2, phase shift = $\pi/6$
 19 $e^{-2t}\sqrt{2} \cos(3t - \pi/4)$, amplitude = $\sqrt{2}e^{-2t}$, frequency = 3, phase shift = $\pi/4$
 21 $e^{-2t}[2 \cos(5t) + \sin(5t)]$

Section 14.7

- 1 $(24/676) \cos t - (10/676) \sin t$ 3 $(1/2)t^2 + (3/16)t - (3/8)$ 5 $0.5e^{2t}$
 7 $-0.2te^{-3t}$ 9 $0.125t \sin(4t)$ 11 $3t^2e^{-6t}$ 13 $Ae^{-3t} + Be^{-2t} + 0.8$
 15 $A \cos(\sqrt{5}t) + B \sin(\sqrt{5}t) + 2 \sin(2t)$ 17 $4e^t + e^{-t} - 3t - 5$
 19 $e^{-6t}[2 \cos t + 20 \sin t] + 2e^{-4t}$
 21 $e^{-2t}[A \cos(5t) + B \sin(5t)] + 25 \cos(2t) + 8 \sin(2t)$, steady state = $25 \cos(2t) + 8 \sin(2t)$
 25 5

Extra Problems for Chapter 14

- 1 $y = -1/(\sin t + C)$ 3 $y = -\ln(-\ln|t| + e^{-2})$ 5 $y = Ce^{-5t^2}$ 7 $y = e^{-6t}$
 9 $y = (2/3)t - 2/9 + Ce^{-3t}$ 11 $y = 3,500,000e^{0.02t} - 2,500,000$
 15 $y = Ae^{4t} + Be^t$ 17 $y = e^{2t}[A \cos(2t) + B \sin(2t)]$ 19 $y = -(1/6)e^{-5t} + (1/6)e^t$
 21 $y = e^{-(3/2)t}[10 \cos(t/2) + 30 \sin(t/2)]$ 23 $y = Ae^{4t} + Be^t + 13/16 + t/4$
 25 $y = -2 \cos t - 3 \sin t - (1/6)e^{-5t} + (13/6)e^t$

INDEX

- Absolute convergence, 521
- Absolute value, 12
 - of a complex number, 876
- Absolute value function, 12
- Acceleration, 94
 - vector, 565, 623
- Addition formulas for sine and cosine, 372
- Addition Property, 190, 303
 - variables
 - two, 712, 720
 - three, 760
- Adiabatic process, 490
- Almost parallel vectors, 632
- Alternating series, 517
 - harmonic, 520, 546
- Alternating Series Test, 518
- Amplitude, 886
- Angle, 77, 365
 - between vectors, 573
 - three dimensions, 588
- Angular measure, 367
- Anticommutative Law for vector products, 604
- Antiderivative, 192
- Approximation
 - by alternating series, 518
 - $\arctan x$, 541
 - by derivatives, 286
 - e , 442, 551
 - $\ln x$, 541
 - by Newton's method, 290
 - π , 542
 - by power series, 541
 - by Riemann sums, 178
 - Simpson's, 230
 - $\sin x$, 552
 - by Taylor's Formula, 547
 - trapezoidal, 226
 - within ϵ , 284
- Arc, 323, 365
 - length, 324, 366, 420
- $\arccos$, 384
- Arccosecant, 384
 - derivative, 387
- Arccosine, 384
 - derivative, 387
 - integral, 392
- arccot , 384
- Arccotangent, 384
 - derivative, 387
- arccsc , 384
- Archimedes, 902
- arcsec , 384
- Arcsecant, 384
 - derivative, 387
 - integral, 473
- $\arcsin$, 384
- Arcsine, 384
 - derivative, 387
 - integral, 392
 - power series, 560
- $\arctan$, 384
- Arctangent, 384
 - derivative, 387
 - integral, 472
 - power series, 536
- Area
 - below a curve, 188
 - between two curves, 220, 304
 - double integral, 722
 - geometric figures, 115
 - by Green's Theorem, 818
 - infinite, 353
 - polar, 421
 - surface, 825
 - surface of revolution, 328
 - under a curve, 188
- Argand diagram, 876
- Argument, complex number, 876
- Associative Law, 905
 - inner product, 597
 - scalar multiples, 570
 - vector product, failure, 602
 - vector sum, 568
- Asymptote
 - of a hyperbola, 270
 - vertical, 251
- Average slope, 22, 168
- Average speed, 339
- Average value, 337
- Average velocity, 169, 339
- Axioms
 - for hyperreal numbers, 906
 - for real numbers, 905
- Axis
 - coordinates
 - plane, 3
 - space, 585
 - ellipse, 264
 - hyperbola, 268
 - parabola, 257
- Barrow, Isaac, 902
- Basis vectors
 - plane, 570
 - space, 587
- Bell-shaped curve, 537
- Berkeley, Bishop, 903
- Binomial series, 558
- Binomial Theorem, 559
- Bound variable, 119, 178

- Boundary
 - oriented surface, 834
 - plane region, 689
 - solid region, 757, 838
- Bounded open region, 694
- Box
 - cylindrical, 770
 - rectangular, 758
 - spherical, 776
- Cantor, Georg, 903
- Capital Accumulation, 452
- Cardioid, 751
- Catenary, 449
- Cauchy, A. L., 903
- Cauchy Convergence Test (Criterion), 500, 504
- Cauchy Divergence Test, 505
- Cauchy equivalence, 911
- Cauchy sequence, 911
- Center
 - circle, 5
 - ellipse, 264
 - hyperbola, 268
 - sphere, 641
- Center of gravity, 344
- Center of mass
 - double integral, 745
 - triple integral, 765
 - two dimensions, 346
 - wire, 344
- Centroid, 346
 - polar region, 430
- Chain Rule
 - for continuous functions, 130
 - variables
 - one, 86
 - two, 672
- Change of variables, 210, 484
- Changing base of logarithms, 439
- Characteristic polynomial, 882
- Circle, 5
 - area, 115
 - polar equation, 410
- Circular cylinder, 644
- Circular helix, 616
- Circulation
 - dimensions
 - two, 820
 - three, 836
- Circumference, 115, 324
- Circumscribed cylinder, 721
- Circumscribed rectangle, 189
- Circumscribed rectangular box, 759
- cis*, 876
- Closed interval, 2
 - hyperreal, 908
- Closed rectangle, 713
- Closed region, 689
 - hyperreal, 700
 - space, 757
- Closure Laws, 905
- Commodity vector, 565
- Common logarithm, 436
- Commutative Law, 905
 - inner product, 597
 - vector product, failure, 602
 - vector sum, 568
- Comparison test, 512, 524
- Completeness axiom, 905
- Completing the square, 274, 479
- Complex number, 874
 - conjugate, 875
 - exponent, 879
 - plane, 874
- Complex valued differential equation, 879
- Complex valued function, 879
- Component
 - directed line segment, 564
 - vector, 565
 - valued function, 615
- Composition of functions, 86
 - continuity, 130, 653
 - derivative, 86, 672
- Concave downward, 152
- Concave upward, 152
- Conditional convergence, 521
- Cone
 - area, 327
 - elliptic, 642
 - volume, 115
- Conic section, 264
- Conjugate axis, 268
- Conjugate complex, 875
- Conservative field, 807
- Constant, 11
- Constant function, 11
 - derivative of, 61
 - integral of, 184
- Constant of integration, 199
- Constant on an interval, 151
- Constant Rule
 - derivative, 61
 - double integral, 732
 - integral, 200
 - series, 508
- Continuity, 125
 - of compositions, 130, 653
 - of differentiable functions, 127
 - ϵ , δ condition, 288
 - of an integral, 192
 - on an interval, 132
 - law of, 902
 - on a set, 653
- two variables, 651
- vector, 635
- Continuously compounded interest, 443, 497
- Contour, 645
- Contour map, 644
- Convergence
 - improper integral, 352
 - increasing sequence, 511
 - interval of, 529
 - positive term series, 511
 - radius of, 530
 - sequence, 493
 - series, 502
 - summary of tests, 525
- Coordinates
 - cylindrical, 769
 - polar, 407
 - rectangular
 - plane, 3
 - space, 585, 639
 - spherical, 775
- cos*, 78, 368
- Cosecant function, 370
 - derivative, 376
- cosh*, 449
 - power series, 536
- Cosine, 78, 368
 - derivative, 79, 374
 - integral, 377
 - power series, 558
- Cosines, Law of, 573
- cot*, 370
- Cotangent function, 370
 - derivative, 376
- coth*, 450
- Critical damping, 887
- Critical point, 136
 - interior, 137
 - two variables, 689
- Critical Point Theorem, 136
 - two variables, 689
- Cross product, 600
- csc*, 370
- csch*, 450
- Curl
 - dimensions
 - two, 819
 - three, 832
- Curve length, 320
 - parametric, 321
 - polar coordinates, 425
 - in space, 622
- Curve sketching
 - using derivatives, 156
 - ellipse, 266
 - hyperbola, 269
 - using limits, 251
 - parabola, 261
 - polar, 415

- rotation of axes, 281
 - translation of axes, 275
 - Cycloid, 616
 - Cylinder
 - area, 327
 - circular, 644
 - quadric, 641
 - volume, 115, 309
 - Cylinder Property, 712, 721
 - Cylindrical box, 770
 - Cylindrical coordinates, 769
 - Cylindrical Integration
 - Formula, 771
 - Cylindrical region, 770
 - Cylindrical shell method, 313
 - Damped oscillation, 887
 - Damping, critical, 887
 - Decreasing on an interval, 152
 - Definite integral, 183
 - Degenerate conic section, 263, 273
 - Degree, angular unit, 367
 - Deleted neighborhood, 243
 - Demand function, 114
 - De Moivre's Formula, 878
 - Density
 - dimensions
 - one, 341
 - two, 342
 - three, 764
 - of a wire, 364
 - Dependent variable, 8, 45
 - Derivative, 45
 - directional, 786
 - exponential function, 83, 443
 - higher, 94
 - higher partial, 703
 - hyperbolic functions, 449
 - inverse trig functions, 387
 - $\ln$, 84, 455
 - mixed partial, 703
 - partial, 656
 - polar coordinates, 414
 - power rule, 63, 76
 - power series, 534
 - rational function, 68
 - rules for, 68
 - sec and csc, 376
 - second, 94
 - second partial, 703
 - sin and cos, 374
 - tan and cot, 376
 - vector, 620
- Determinant, 600
 - Difference, vector, 569
 - Differentiable function, 45
 - continuity of, 127
 - on an interval, 132
 - two variables, 710
 - Differential, 55
 - exact, 806
 - form, 806
 - second, 94
 - total, 662
 - vector, 633
 - Differential equation
 - complex valued, 879
 - exact, 810
 - first order, 461, 846
 - homogeneous, 852, 882
 - linear, 857
 - second order, 461, 881
 - separable variables, 848
 - Differentiation, 45
 - logarithmic, 470
 - rules for, 68
 - Direct Test, 137
 - Directed curve, 795
 - Directed line segment, 564
 - Direction angle, 574, 588
 - Direction cosine, 574, 588
 - Direction, real, 630
 - Direction vector
 - of a line, 578, 590
 - of a plane, 606
 - Directional derivative, 786
 - second, 793
 - three dimensions, 791
 - Directrix, parabola, 257
 - Disc method, 309
 - Discontinuity, 125
 - Discriminant, 875
 - test, 273
 - two variables, 273
 - Displacement vector, 565
 - Distance
 - plane, 4
 - between reals, 13, 282
 - space, 641
 - Distributive Law, 905
 - scalar multiples, 570
 - products
 - inner, 597
 - vector, 602
 - Divergence
 - dimensions
 - two, 819
 - three, 833
 - Theorem, 839
 - Divergent
 - improper integral, 352
 - sequence, 494
 - series, 502
 - Domain, 10
 - Dot product, 593
 - Double integral, 711, 719
 - Double Riemann sum, 715
 - infinite, 719
 - Dummy variable, 119, 178
 - e , 83, 443
 - irrationality of, 563
 - as a limit, 443
 - Element
 - of area, 736
 - of a set, 2
 - of volume
 - cylindrical, 772
 - rectangular, 764
 - spherical, 777
 - Elementary function, 481
 - Ellipse, 264
 - sketching method, 266
 - Ellipsoid, 642
 - Elliptic cone, 642
 - Elliptic cylinder, 641
 - Elliptic paraboloid, 642
 - Empty set, 3
 - Endpoint, 2
 - Epidemic, 463
 - ϵ , δ condition
 - continuity, 288
 - derivative, 295
 - limits, 283, 286
 - ϵ , N condition
 - for infinite limits, 499
 - for sequences, 499
 - Equality of mixed partials, 703
 - three variables, 705
 - Equation, 906
 - differential, 461, 846
 - linear, 20
 - parametric, 90
 - point-slope, 16
 - second degree, 272
 - two-point, 18
 - Error estimate, 228, 296
 - for derivatives, 296
 - for Simpson's Rule, 231
 - and Taylor's Formula, 550
 - for trapezoidal sums, 228
 - Escape velocity, 491
 - Euler approximation, 865
 - Euler's Formula, 879
 - Even function, 218
 - Exact differential, 806
 - equation, 810
 - Existence Theorem, differential equations, 867
 - $\exp$, 443
 - Explosion, 851, 871
 - Exponent
 - complex, 879
 - inequalities, 432
 - real, 432
 - rules, 432

- Exponential function, 83, 443
 - with base, 82, 432
 - continuity, 433
 - derivative, 83, 443
 - integral, 444
 - power series, 536
- Exponential spiral, 448
- Expression, real, 28, 906
- Extension Axiom, 906
- Extension Principle, 27
- Extreme Value Theorem, 164
 - two dimensions, 689
- Factor Theorem, 477
- Factorial, $n!$, 493
- Fermat, P., 902
- Finite
 - hyperreal number, 30
 - partition, 160
 - Riemann sum, 178
 - set, 3
 - vector, 627
- First Derivative Test, 174
- First order differential equation, 461
- Fluid flow, 820
- Flux, 821
- Focus
 - ellipse, 264
 - hyperbola, 268
 - parabola, 257
- Force vector, 565
- Forcing term, 892
- Formula, 45, 906
- Frequency, 886
- Frustum, area, 328
- Fubini's Theorem, 726
- Function, 45
 - hyperreal, 27
 - implicit, 97
 - inverse, 70, 381
 - linear, 17
 - real, 6
 - two variables, 14
 - vector-valued, 615
- Fundamental Theorem of Calculus, 193
- Galileo, G., 902
- Gauss' Theorem, 839
- General solution, 461, 846
- Generalized Mean Value Theorem, 552
- Geometric series, 503
 - formula, 446
- Gödel, Kurt, 904
- $\text{grad } f$, 787
- Gradient, 787
- Graph, 7
 - dimensions
 - one, 7
 - two, 640
 - of an equation, 5
 - infinite sequence, 492
 - polar coordinates, 408
 - space, 639
- Gravity
 - dimensions
 - one, 491
 - two, 809
 - three, 843, 844
- Greatest integer function, 130
- Green's Theorem, 815
 - vector form, 820
- Growth rate, 51
 - populations, 51, 462, 491
 - sequences, 497
- Half-life, 463
- Half-open interval, 2
- Harmonic series, 505
 - alternating, 546
- Helix, circular, 616
- Hewitt, E., 904
- Higher derivative, 94
 - partial, 703
- Higher differential, 94
- Homogeneous differential equation, 852
 - second order, 882
 - solution, 852, 886
- Homogeneous function, 710
- Horizontal axis, 3
- Horizontal ellipse, 266
- Horizontal parabola, 261
- Hyperbola, 268
 - graphing method, 270
- Hyperbolic cosine, 449
 - derivative, 449
 - integral, 449
- Hyperbolic cylinder, 641
- Hyperbolic function, 449
- Hyperbolic identities, 449
- Hyperbolic paraboloid, 643
- Hyperbolic sine, 449
 - derivative, 449
 - integral, 449
- Hyperboloid, 643
- Hyperinteger, 160
- Hyperrational number, 431
- Hyperreal function, 27
- Hyperreal interval, 161, 908
- Hyperreal number, 27
- Hyperreal region, 697
- Hyperreal vector, 627
- i , 874
- Identity function, 12
- Identity Law, 905
 - vector sum, 568
- Imaginary number, 874
- Imaginary part, 874
- Implicit differentiation, 97
- Implicit function, 97
 - derivative of, 97, 680
 - two variables, 680
- Implicit Function Theorem, 680
- Improper integral, 352
- Incompressible field, 822
- Increasing function, 151
- Increasing sequence, 511
- Increment, 45
 - two variables, 662
 - vector, 633
- Increment Theorem, 54, 299
 - variables
 - two, 664
 - three, 670
- Indefinite integral, 199
- Independent variable, 8, 45
- Indeterminate form, 31
- Induction, Principle of, 64
- Inequalities for exponents, 432
- Inequality, 906
- Inequality Rule
 - double integral, 733
 - series, 508
- Inertia, moment of
 - dimensions
 - two, 748
 - three, 767
- Infinite hyperreal number, 24
 - examples, 912
- Infinite partial sum, 502
- Infinite partition, 161
- Infinite Riemann sum, 181
 - double, 719
- Infinite sequence, 492
- Infinite series, 502
- Infinite Sum Theorem, 303
 - double integral, 736
 - triple integral, 764
- Infinite telescope, 24
- Infinite vector, 627
- Infinitely close, 24, 35
 - compared to, 302
 - two dimensions, 651
 - vectors, 627
- Infinitesimal, 24, 28
 - examples, 913
 - microscope, 24
 - vector, 627
- Inflection, point of, 156
- Initial condition, 462, 847, 881
- Initial point
 - directed line segment, 564
 - smooth curve, 795
- Initial value problem
 - first order, 847

- second order, 881
- Inner product, 594
 - derivative, 625
 - rules, 597
- Inscribed cylinder, 721
- Inscribed rectangle, 189
- Integers, 3
- Integral
 - arcsec and arccsc, 473
 - arcsin and arccos, 392
 - arctan and arccot, 472
 - definite, 183
 - double, 711, 719
 - exponential function, 443
 - improper, 352
 - indefinite, 199
 - iterated, 724
 - line, 795
 - ln, 456
 - partial, 798
 - power series, 534
 - rational functions, 477
 - sin and cos, 377
 - sinh and cosh, 449
 - surface, 829
 - tan, 471
 - triple, 760
- Integral Test, 514
- Integration
 - change of variables, 210, 484
 - coordinates
 - cylindrical, 771
 - polar, 751
 - spherical, 777
 - methods of, 481
 - by parts, 391, 394
 - substitution, 210, 484
 - trigonometric, 403, 485
- Interest, 442, 451
- Interior point, 137, 689
 - critical, 137
- Intermediate Value Theorem, 162
- Intermediate variable, 671
- Interval, 2
 - of convergence, 529
 - hyperreal, 161, 908
- Inverse function, 70, 381
 - hyperbolic, 461
 - trigonometric, 384
- Inverse Function Rule, 72
- Inverse Function Theorem, 386
- Inverse Laws, 905
- Inverse relation, 381
- Inverse square law, 491
- Irrrotational field, 822
- Iterated integral, 724
- Iterated Integral Theorem
 - double, 725
 - triple, 761
- Judicious guessing, 893
- Justification of a definition, 304
- Kepler, J., 902
- Kinetic energy, 784
- Kline, Morris, 907
- Law of continuity, 902
- Law of Cosines, 573
- Least squares, method of, 702
- Leibniz, Gottfried Wilhelm, 902
- Length
 - arc, 366
 - curve, 320
 - parametric, 321
 - space, 622
 - polar coordinates, 425
 - real, 630
 - vector, 566
- Level curve, 645
- Level surface, 791
- l'Hospital's Rule
 - for $0/0$, 243
 - for ∞/∞ , 246
- Limit, 117
 - and curve sketching, 251
 - ϵ, δ condition, 283, 286
 - finite, 117
 - from the left, 123
 - from the right, 123
 - infinite, 237
 - one-sided, 123
 - of a Riemann sum, 188, 316
 - rules, 121
 - sequence, 493
 - and standard parts, 120
 - two variables, 656
- Limit Comparison Test, 513, 524
- Line, 16
 - equation of, 16, 18, 20
 - polar equation, 409
 - space, 589
 - vector equation, plane, 578
 - vector equation, space, 589
 - vertical, 16
- Line integral, 795
- Linear differential equation, 857
 - second order, 892
 - solution, 858, 862, 897
- Linear equation, 20
- Linear function, 17, 60
- ln, 83, 454
 - integral, 456
 - power series, 536
- Local maximum, 156
- Local minimum, 156
- Locus
 - of an equation, 7
 - polar coordinates, 408
 - space, 639
- Logarithm
 - changing base, 439
 - common, 436
 - natural, 83, 454
 - rules, 437
- Logarithmic differentiation, 470
- Logarithmic function, 436
- Logistic function, 464
- Lower endpoint, 2
- MacLaurin series, 555
- MacLaurin's Formula, 550
- Magnitude, 567
- Major axis, ellipse, 264
- Malcev, A., 904
- Map, 209
- Marginal price vector, 624
- Marginal revenue, 114
- Marginal values, 51
- Mass
 - dimensions
 - one, 341
 - two, 342
 - double integral, 743
 - triple integral, 764
- Mass-spring system, 888
- Maximum, 135
 - closed region, 691
 - local, 156
 - open region, 698
 - two variables, 688
 - value, 135
- Mean Value Theorem, 168
 - generalized, 552
 - for Integrals, 338
- Member of a set, 2
- Method of least squares, 702
- Methods of integration, 481
- Midpoint, 582, 592
- Minimum, 135
 - local, 156
 - two variables, 688
 - value, 135
- Minor axis, ellipse, 264
- Mixed partial derivative, 703
- Model theory, 904
- Moment
 - dimensions
 - one, 343
 - two, 345
 - double integral, 744
 - triple integral, 765
 - wire, 344

- Moment of inertia (second moment),
 - dimensions
 - two, 748
 - three, 767
- Natural extension, 906
- Natural logarithm, 81, 454
 - derivative, 84, 455
 - integral, 456
- Negative infinite, 24, 30
- Negative infinitesimal, 28
- Neighborhood, 243
 - deleted, 243
- Newton, Sir Isaac, 902
- Newton's First Law, 567
- Newton's Law of Cooling, 490
- Newton's method, 290
- Newton's Second Law, 570
- Nonstandard analysis, 904
- Nonuniqueness, differential equation, 872
- Norm of a vector, 566
- Normal curve, 537
- Normal vector
 - curve, 606
 - surface, 828
- n th derivative, 94
- n th differential, 94
- Odd function, 218
- One-to-one function, 382
- Open interval, 2
- Open rectangle, 794
- Open rectangular solid, 803
- Open region, 694
- Ordered pair, 3
- Oriented surface, 828
- Origin, 3
 - in polar coordinates, 412
- Orthogonal vectors, 597
- Oscillation
 - damped, 887
 - simple, 886
- Overdamping, 888
- p series, 515
- Parabola, 257
 - graphing method, 261
- Parabolic cylinder, 641
- Paraboloid
 - elliptic, 642
 - hyperbolic, 643
- Parallel line and plane, 609
- Parallel planes, 609
- Parallel, test for, 597
- Parallel vectors, 597
- Parallelogram, 583
 - area, 604
- Parametric curve, 90
- Parametric equations, 90
 - of a line, 579, 590
 - polar coordinates, 411
 - and vector equations, 579, 615
- Partial derivative, 656
 - higher, 703
 - implicit function, 686
 - mixed, 703
 - second, 703
 - three variables, 659
- Partial fraction, 477
- Partial integral, 798
 - derivative of, 811
- Partial second derivative, 703
- Partial sum, 502
- Particular solution, 846
- Partition
 - finite, 160
 - infinite, 161
 - of a rectangle, 715
 - of a rectangular box, 759
- Partition point, 161, 176
- Path Independence Theorem, 806
- Perimeter, 115
- Period, 886
- Periodic function, 368
- Perpendicular line and plane, 609
- Perpendicular planes, 609
- Perpendicular, test for, 597
- Perpendicular vectors, 597
- Phase shift, 886
- Pi, π , 366
- Piecewise continuous, 357
- Piecewise smooth, 800
- Plane, 4, 604
- Point, 3
- Point of inflection, 156
- Point-slope equation, 16
- Polar coordinates, 407
 - area, 421
- Polar equation
 - circle, 410
 - line, 409
- Polar form, complex numbers, 876
- Polar Integration Formula, 751
- Polar rectangle, 750
- Polar region, 750
- Polynomial, 60
 - function, 60
- Population growth, 434, 442, 463
- Position, 203
- Position vector, 565
 - of a curve, 615
 - of a line, 578, 590
 - of a plane, 606
 - of a point, 576, 589
- Positive infinite, 24, 30
- Positive infinitesimal, 28
- Positive term series, 511
- Potential function, 805
 - existence, 806
 - method for finding, 807
 - three variables, 814
- Potential energy, 807
- Power Rule
 - derivatives, 63
 - general form, 89
 - integrals, 200, 471
 - negative exponents, 66
 - rational exponents, 76
- Power series, 528
 - multiplication of, 563
 - operations on, 535
 - steps for finding, 557
 - table, 556
- Present value, 454
- Pressure, 364
- Price vector, 565
- Principle of Induction, 64
- Principle of Superposition, 863, 896
- Prism, volume, 115
- Product
 - function, 648
 - inner, 594
 - vector, 600
- Product Law, order axiom, 905
- Product Rule
 - derivative, 62
 - vector derivative, 625
- Profit, 137
- Pyramid, volume, 306
- Pythagoras, Theorem of, 5
- Quadrant, 4
- Quadratic formula, 103, 477
 - complex, 875
- Quadric cylinder, 641
- Quadric surface, 640
- Quotient function, 652
- Quotient Rule, derivatives, 66
- R , 1
- R^* , 24
- Radian, 78, 367
- Radioactive decay, 463
- Radius
 - of circle, 5
 - of convergence, 530
 - of sphere, 641
- Range, 10
- Rate of growth, 51, 434, 442, 463

- Ratio Test, 524
- Rational function, 60, 474
 - differentiation, 68
 - integration, 477
- Rational number, 3
- Rational term, 60
- Real direction, 630
- Real expression, 906
- Real length, 630
- Real line, 1
- Real number, 1
- Real part, 874
- Real statement, 907
- Real term, 906
- Real vector, 630
- Rearrangement, series, 523
- Reciprocal function, 8
- Rectangle
 - area, 115
 - closed, 713
 - open, 794
 - polar, 750
- Rectangle Property, 188
- Rectangular box, 758
- Rectangular coordinates
 - plane, 3
 - space, 585, 639
- Rectangular solid, 115, 758
- Reduction formula
 - secant and cosecant, 399
 - sine and cosine, 398
 - tangent and cotangent, 397
- Region
 - below a curve, 175
 - between two curves, 218, 717
 - bounded, 694
 - closed, 689
 - cylindrical, 770
 - hyperreal, 697
 - open, 694
 - polar, 750
 - solid, 757
 - spherical, 775
 - unbounded, 694
 - under a curve, 175
- Related rates, 112
- Relativity, theory of, 239
- Resonance, 897
- Resonant frequency, 900
- Revenue, 114
- Riemann sum, 176, 178
 - double, 715
 - finite, 178
 - infinite, 181
 - infinite double, 719
 - triple, 759
- Right-handed coordinates, 585
- Robinson, Abraham, 904
- Rolle's Theorem, 165
- Root, 2
- Root Axiom, 905
- Rotation of axes, 280
 - equations, 277
- Saddle point, 690
- Scalar, 566
- Scalar Associative Law, 570
- Scalar equation
 - of a line, 577
 - of a plane, 604
- Scalar multiple, 570
 - derivative, 627
- Scalar product, 593
- Scalar triple product, 604
- Schwartz' Inequality
 - integrals, 236
 - vectors, 637
- sec*, 370
- Secant function, 370
 - derivative, 376
 - integral, 471
- Secant line, 295
- sech*, 450
- Second degree equation
 - variables
 - two, 272
 - three, 640
- Second derivative, 94
 - partial, 703
- Second Derivative Test, 138
 - two variables, 707
- Second differential, 94
- Second order differential
 - equation, 461
- Second partial derivative, 703
- Sector, 365
 - area, 115, 324, 366, 420
- Separable variables, 465, 848
 - solution method, 848
- Sequence
 - graph of, 492
 - increasing, 511
 - infinite, 492
 - of partial sums, 502
- Series, 502
 - absolutely convergent, 521
 - alternating, 517
 - conditionally convergent, 521
 - convergent, 502
 - divergent, 502
 - of functions, 528
 - infinite, 502
 - positive term, 511
 - sum, 502
 - summary of tests, 525
 - tail, 508
 - Taylor, 554
 - telescoping, 506
- Set, 2
- Side condition, 692
- Simple closed curve, 801
- Simple oscillation, 886
- Simpson's approximation, 230
- Simpson's Rule, 231
- sin*, 77, 368
- Sine, 77, 368
 - derivative, 79, 374
 - integral, 377
 - power series, 558
- sinh*, 449
 - derivative, 449
 - integral, 449
 - power series, 537
- Skolem, Thoralf, 903
- Slide rule, 438
- Slope
 - average, 22, 168
 - curve, 25, 43
 - directional, 786
 - function, 43
 - implicit function, 680
 - as a limit, 119
 - line, 16
 - polar coordinates, 413
- Slope-intercept equation, 17
- Smooth curve, 319, 795
 - piecewise, 800
 - space, 803
- Smooth function, 662, 824
 - continuity of, 666
- Smooth surface, 662, 824
- Snail, 448
- Solenoidal field, 822
- Solid region, 757
- Solution, differential
 - equation, 461, 846
- Speed, 623
- Sphere, 641
 - surface area, 115, 333
 - volume, 115, 317
- Spherical box, 776
- Spherical coordinates, 775
- Spherical Integration
 - Formula, 777
- Spherical region, 775
- Spiral
 - of Archimedes, 411, 474
 - exponential, 448
 - vertical, 616
- Spring constant, 888
- Square function, 8
- Square root, 2
- st*, 36
- Standard part, 36
 - function, 910
 - principle, 36, 908
 - rules, 37
 - vector, 629

- Statement, real, 907
- Steady state part of the
 - solution, 899
- Steepest ascent, 788
- Steepest descent, 788
- Stokes' Theorem, 834
- Straight line, 16
 - in space, 589
- Strictly between, 2
- Strictly within, 282
- Subinterval, 160
- Subrectangle, 715
- Substitution, integration by,
 - 210, 484
 - trigonometric, 402
- Sum
 - function, 648
 - partial, 502
 - Riemann, 178
 - series, 502
 - trapezoidal, 226
 - vector, 567
- Sum Law, order axiom, 905
- Sum Rule
 - derivatives, 61
 - double integral, 732
 - integral, 200
 - series, 508
 - use in integration, 483
 - vector derivative, 625
- Surface
 - area, 328, 825
 - area, polar, 428
 - as a boundary, 834
 - contour map of, 644
 - implicit, 686
 - integral, 829
 - level, 791
 - oriented, 828
 - quadric, 640
 - of revolution, 327
 - sketching method, 645
 - smooth, 662, 824
 - tangent plane of, 666
 - topographic map of, 644
- Symmetric region, 784
- Symmetry and center of mass,
 - 347
- System of formulas, 45
- Tail rule, 508
- Tail, series, 508
- tan* 79, 370
- Tangent of an angle, 79
- Tangent function, 370
 - derivative, 376
 - integral, 471
- Tangent line, 53
 - of an implicit function, 686
 - in polar coordinates, 412
 - in space, 621
 - and vector derivatives, 620
- Tangent plane, 666
 - of an implicit function, 686
- Tangent vector, 621
- tanh*, 450
- Tarski, Alfred, 904
- Taylor's Formula, 550
- Taylor polynomial, 549
- Taylor remainder, 549
- Taylor series, 554
 - table of, 556
- Telescoping series, 506
- Term, 9
 - real, 906
- Terminal point
 - directed line segment, 564
 - smooth curve, 795
- Third partial derivative, 704
- Topographic map, 644
- Torus, 336
- Total differential, 662
 - three variables, 669
- Transfer Axiom, 908
- Transfer Principle, 28
- Transient part of solution, 899
- Transitive Law, 905
- Translation of axes, 275
- Transverse axis, 268
- Trapezoidal approximation,
 - 226
- Trapezoidal Rule, 228
- Trapezoidal sum, 226
- Triangle, area, 115
- Triangle inequality, 568
- Trichotomy Law, 905
- Trigonometric functions, 365
- Trigonometric identities, 372
- Trigonometric substitution,
 - 402
- Triple integral, 760
- Triple Riemann sum, 759
- Two-point equation, 18
- Ultraproduct, 903
 - equivalence, 912
- Unbounded open region, 694
- Undefined term, 6
- Undetermined coefficients,
 - 893
- Uniqueness Theorem
 - differential equations, 870
 - double integrals, 722
- Unit circle, 365
- Unit hyperbola, 450
- Unit vector, 570, 588
- Upper endpoint, 2
- Variable, 8, 45
 - bound, 119, 178
 - dependent, 8, 45
 - dummy, 119, 178
 - independent, 8, 45
 - intermediate, 671
 - point, 578
 - vector, 578, 589
- Variation of constants, 857
- Vector, 565
 - continuous, 635
 - derivative, 620
 - difference, 569
 - differential, 633
 - dimensions
 - n , 586
 - two, 565
 - three, 586
 - direction, 578, 606
 - equation, 615
 - of a line, 578, 589
 - of a plane, 606
 - field, 805
 - finite, 627
 - function, 615
 - hyperreal, 627
 - increment, 633
 - infinite, 627
 - infinitesimal, 627
 - negative, 569
 - normal, 606, 828
 - position, 565
 - product, 600
 - derivative, 627
 - real, 630
 - rules, 625
 - sum, 567
 - valued function, 615
 - variable, 578, 589
- Velocity, 23
 - average, 169
 - and integration, 203
 - vector, 565, 622
- Vertex, parabola, 257
- Vertical axis, 3
- Vertical ellipse, 266
- Vertical line, 16
- Vertical parabola, 259
- Volume, 305
 - below a surface, 723
 - between two surfaces, 738
 - cylindrical shell method,
 - 313
 - disc method, 309
 - as a double integral, 723
 - element of, 764
 - function, 711, 722
 - geometric figures, 115
 - as the integral of area, 305
 - solid of revolution, 309, 313
 - as a triple integral, 763, 778
 - under a surface, 723

- Water pressure, 364
- Wave equation, 708
- Weierstrass, Karl, 903
- Work
 - against gravity, 348
 - as an inner product, 595
 - as a line integral, 796
 - as a single integral, 349
- x -axis, 3
- x -component, 564, 586
- x -coordinate, 3
- (x, y) plane, 3, 639
- (x, z) plane, 639
- (x, y, z) space, 585, 639
- y -axis, 3
- y -component, 564, 586
- y -coordinate, 3
- (y, z) plane, 639
- z -axis, 585, 639
- z -component, 586
- Zero of a function, 161
- Zero vector, 567