Answers, Even-Numbered Problems, Chapter 9

9.2

(a) 199 rad/s

(b). $3.1 \times 10^{-3} \text{ s}$

9.4

(a) $(-1.60 \text{ rad/s}^3)t.$

(b) $-4.80 \text{ rad/s}^2.$

$-2.40 \text{ rad/s}^2,$

9.6

(a) $4.23 \text{ s}.$

(b) $-78.1 \text{ rad/s}^2.$

(c) $\theta = 586 \text{ rad} = 93.3 \text{ rev}.$

(d) $250 \text{ rad/s}.$

(e) $138 \text{ rad/s}.$

9.8

(a) The angular acceleration is positive, since the angular velocity increases steadily from a negative value to a positive value.

(b) It takes 3.00 seconds for the wheel to stop $(\omega_z = 0)$. During this time its speed is decreasing. For the next 4.00 s its speed is increasing from 0 rad/s to $+8.00 \text{ rad/s}$.

(c) 1.00 rad/s. 7.00 rad after 7.00 s.

9.10

(a) $-1.25 \text{ rev/s}^2; \ 23.3 \text{ rev}$

(b) 2.67 s

9.12

(b) 8.00 rad/s^2

9.14

$23.3 \text{ rad/s}^2; \ 420 \text{ rad}$

9.16

(a) $1.81 \text{ s}.$

(b) 3.84 rad/s^2

9.18

Let $\theta_0 = 0$. The following table gives the revolutions and the angle θ (in degrees) through which the wheel has rotated for each instant in time (in seconds) and each of the three situations:

t	(a)		(b)		(c)	
	rev	θ	rev	θ	rev	θ
0.05	0.50	180	0.03	11.3	0.44	158
0.10	1.00	360	0.13	45	0.75	270

0.15	1.50	540	0.28	101	0.94	338
0.20	2.00	720	0.50	180	1.00	360

The θ and ω_z graphs for each case are given in Figures 9.18 a–c.

EVALUATE: The slope of the $\theta(t)$ graph is $\omega_z(t)$ and the slope of the $\omega_z(t)$ graph is $\alpha_z(t)$.

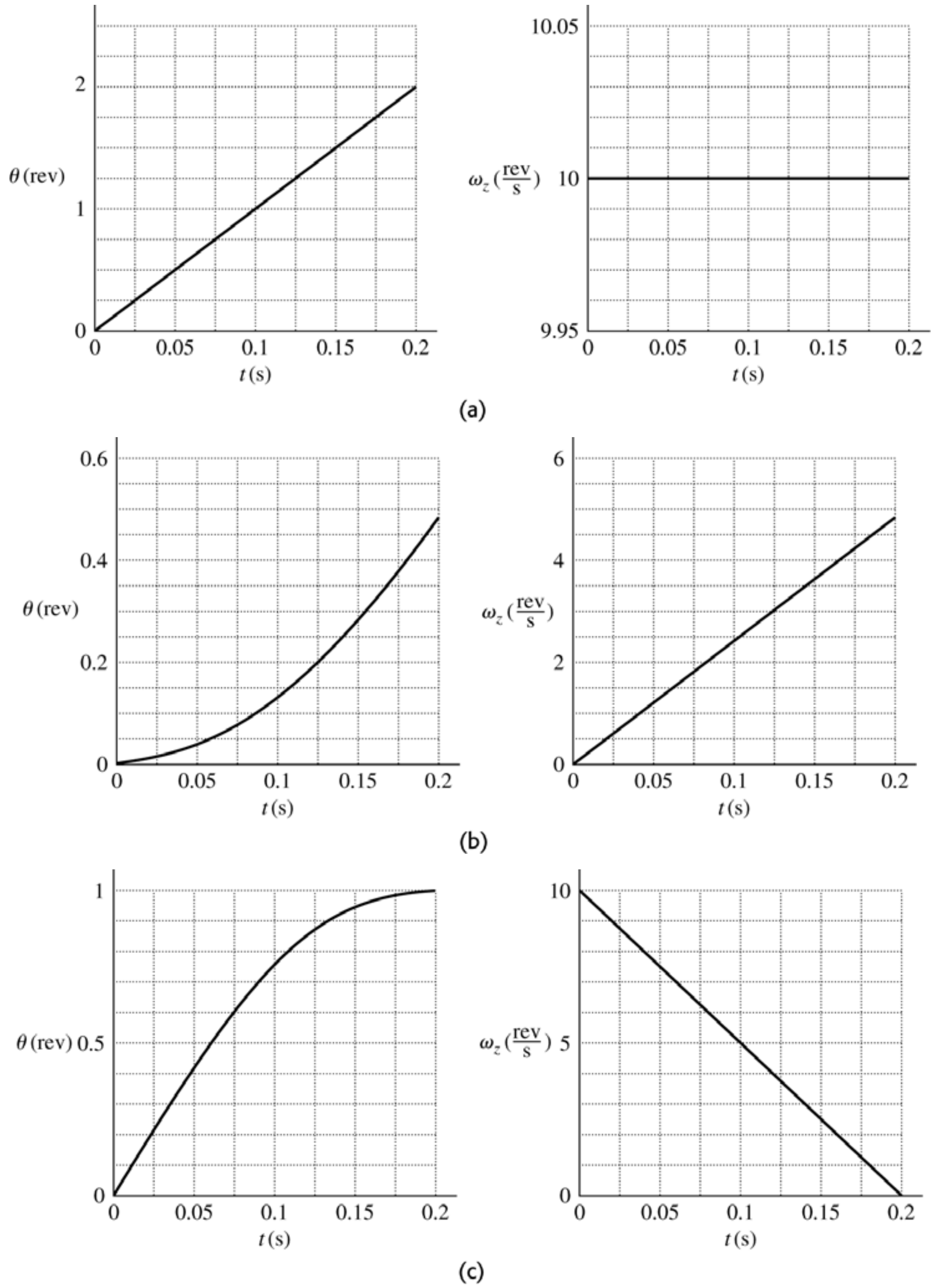

Figure 9.18

9.20

(a) $0.200\ \text{rad/s} = 1.91\ \text{rpm}$.

(b). $0.980\ \text{rad/s}^2$.

(c). $2.60 \text{ rad} = 149°$.

9.22

(a) $50.0 \text{ rad/s},, \quad 21.6 \text{ rad/s}.$

(b) (5.55 km.

(c) $-6.41\times10^{-3} \text{ rad/s}^2.$

9.24

$1.25\times10^4 \text{ rad/s} = 1.20\times10^5 \text{ rpm}$

9.26

(a) 0.430 rev/s

(b) 0.068 rev.

(c) $1.01 \text{ m/s}.$

(d) 3.46 m/s^2 .

9.28

(a) $a_{\text{rad}} = \omega^2 r = \omega^2\left(\frac{v}{\omega}\right) = \omega v.$

(b) 0.250 rad/s.

9.30

(a) -50.0 rad/s^2

(b) At $t = 3.00 \text{ s}$, 250 rad/s and at $t = 0,$, 400 rad/s.

(c) 155 rev.

(d) $1.40 \text{ m/s}.$ This speed will be reached at time $t = 7.86 \text{ s}$.

9.32

(a). 5.09 cm.

(b). 15.7 rad/s^2 .

9.34

(a) $0.0640 \text{ kg}\cdot\text{m}^2$

(b) $0.0320 \text{ kg}\cdot\text{m}^2$

(c) $0.0320 \text{ kg}\cdot\text{m}^2$

9.36

(a) $\frac{1}{2}mL^2$.

(b) $\frac{11}{16}mL^2$.

9.38 $\left(\frac{1}{12}M + \frac{1}{2}m\right)L^2$

9.40

(a $\frac{1}{2}MR^2$.

(b) The same mass *M* is distributed the same way as a function of distance from the axis.

(c) $\frac{1}{2}MR^2$.

9.42

(a).. $1.33\times10^6\ \text{J}$.

(b) $2770\ \text{rpm}$

9.44

(a) $0.0225\ \text{kg}\cdot\text{m}^2$.

(b) $0.500\ \text{kg}$.

9.46

$14.7\ \text{N}$.

9.48

(a) $v=\sqrt{\dfrac{2gh}{1+M/m}}$.

(b) This expression is smaller than that for the solid cylinder; more of the cylinder's mass is concentrated at its edge, so for a given speed, the kinetic energy of the cylinder is larger. A larger fraction of the potential energy is converted to the kinetic energy of the cylinder, and so less is available for the falling mass.

9.50

$\frac{1}{4}mR^2\omega^2$. $I=\frac{1}{2}mR^2$.

9.52

17.7 J.

9.54

$2MR^2$.

9.56

$\dfrac{M}{3}L^2$.

9.58

(a) $I=\frac{1}{12}Ma^2$.

(b $I=\frac{1}{12}Mb^2$.

9.60

$M\left[\dfrac{1}{3}L^2-Lh+h^2\right]$,

which is the same as found in Example 9.11.

EVALUATE: Example 9.11 shows that this result gives the expected result for $h=0$, $h=L$ and $h=L/2$.

9.62

$\frac{1}{3}ML^2$

9.64

(a) For a counterclockwise rotation, $\vec{\omega}$ will be out of the page.

(b) The upward direction crossed into the radial direction is, by the right-hand rule, counterclockwise. $\vec{\boldsymbol{\omega}}$ and $\vec{\mathrm{r}}$ are perpendicular, so the magnitude of $\vec{\boldsymbol{\omega}} \times \vec{\mathrm{r}}$ is $\omega r = v$.
(c) $\vec{\boldsymbol{\omega}}$ is perpendicular to $\vec{\mathrm{v}}$ and so $\vec{\boldsymbol{\omega}} \times \vec{\mathrm{v}}$ has magnitude $\omega v = a_{\mathrm{rad},}$ and from the right-hand rule, the upward direction crossed into the counterclockwise direction is inward, the direction of $\vec{\mathrm{a}}_{\mathrm{rad}}$.

9.66

(a) $2\gamma t - 3\beta t^2$
(b) $2\gamma - 6\beta t$
(c) $2.133\ \mathrm{s}$; 6.83 rad/s
The maximum positive angular velocity is 6.83 rad/s and it occurs at 2.13 s.

9.68

(a)
$35.0\ \mathrm{km/h} = 9.72\ \mathrm{m/s}$
(b) $8.50\ \mathrm{J}$
(c) $652\ \mathrm{rad/s}$

9.70

(a). $13.2\ \mathrm{m}$.
(b). $8.04\ \mathrm{m/s}$

9.72

(a) $75.1\ \mathrm{m/s}$.
(b) $5.43 \times 10^4\ \ \mathrm{m/s^2}$,

9.74

$0.70\ \mathrm{kg \cdot m^2}$.

9.76

$6.67 \times 10^{-3}\ \mathrm{kg \cdot m^2}$

9.78

$M_{\mathrm{hollow}} = \frac{3}{5} M_{\mathrm{solid}} = \frac{3}{5} M$.

9.80 $\omega = \sqrt{\frac{4}{3}\frac{g}{R}}$.

9.82

(a) $0.622\ \mathrm{kg \cdot m^2}$.
(b) $3.92\ \mathrm{kg \cdot m^2}$. The boss's wheel is physically impossible.

9.84 $\omega = \sqrt{\omega_0^2 + \frac{(4\pi m g/R)}{(M + 2m)}}$, and the speed of any part of the rope is $v = \omega R$.

9.86

$2.81 \ \mathrm{m/s}$.

9.88

(a) $2.00\times10^{7}\ \mathrm{J}$.

(b) $1.08\times10^{3}\ \mathrm{s}=17.9\ \mathrm{min}$.

9.90

(a) $h' = \dfrac{h}{1+\ M/2m}$.

(b) Considering the system as a whole, some of the initial potential energy of the mass went into the kinetic energy of the cylinder. Considering the mass alone, the tension in the string did work on the mass, so its total energy is not conserved.

9.92

$v_{\mathrm{B}} 3.68\ \mathrm{m/s}$.

9.94

(b) $(I_{\mathrm{rod}}/ML^2) = (m_{\mathrm{rod}}/3M),$ which is 0.33% when $m_{\mathrm{rod}} = (0.01)M$.

9.96

If all the mass of a side were at its center, a distance $a / 2$ from the axis, we would have $I = 4\left(\dfrac{M}{4}\right)\left(\dfrac{a}{2}\right)^2 = \dfrac{1}{4}Ma^2$. If all the mass was divided equally among the four corners of the square, a distance $a / \sqrt{2}$ from the axis, we would have $I = 4\left(\dfrac{M}{4}\right)\left(\dfrac{a}{\sqrt{2}}\right)^2 = \dfrac{1}{2}Ma^2$.

The actual *I* is between these two values.

9.98

(a)..$1.09\times10^{38}\ \mathrm{kg}\cdot\mathrm{m}^2$

(b) $9.9\times10^{3}\ \mathrm{m},\ \text{about } 10\ \mathrm{km}.$

(c) $1.9\times10^{6}\ \mathrm{m/s} = 6.3\times10^{-3}c.$

(d) $6.9\times10^{17}\ \mathrm{kg/m^3}$, which is much higher than the density of ordinary rock by 14 orders of magnitude, and is comparable to nuclear mass densities.

9.100

$I = \dfrac{3}{10}MR^2.$