Answers to Example Problems - Chapter 11

EX CJ.) The ball would rise to the same vertical height above the surface of the desk, regardless of the length of the ramp. If there were no ramps, it would continue to roll forever.

EX CK.) $v_f = v_i + at$
$a = -\ 21.4\ m/s^2$

$F = ma$
$F = 1498\ N$ (about 330 lbs)

EX CL.) $F = ma$
$a = 67\ m/s^2$

$v_f^2 = v_i^2 + 2a\Delta x$
$v_f = 458\ m/s^2$
thus they escape

EX CL.) Gravity and the plane act on the ball. The acceleration acts down the plane. The net force must act in the same direction. There must be a force other than gravity acting on the ball.

EX CM.) No. Your push and also a force from the ground acting against your push to cancel it out.

EX CN.) Net force equals zero, but gravity, the road, air resistance and the push from the road on the tires act on your car.

EX CN.) The forces are air resistance, gravity, and the runway. If the engines are used to stop the plane, then they also create a force. The acceleration is backwards.

EX CO.) Friction must act on the car and it must act in towards the center of the circle.

EX CP.) The plane must act upwards to the left at an angle in order to change the velocity as shown.

EX CQ.) a.) Magnet B would move over to magnet A
b.) The two magnets would move towards each other.
equal force on each magnet, the accelerations would be the same.

EX CR.) a.) Magnet A would move over to magnet A
b.) The two magnets would move towards each other.
equal force on each magnet, the accelerations would be different, in porportion to their masses.

EX CS.) Gravity. The reaction force is you pulling up on the earth. It causes the earth to move up to you.

EX CT.) The spool will move to the right. Force is to the right, thus acceleration must be to the right.

EX CU.) No forces (no acceleration).

EX CV.) You walk because you push on the earth and the earth pushes back on you. If the earth had the same mass as you did, it would go backwards as fast as you go forward.

EX CV.) Cart will move to the left. Fan pushes on air, air pushes on fan.

EX CW.) Fan pushes on air, air pushes on fan. Air pushes on sail, sail pushes on air. The air on the sail is stronger. The cart goes to the right.

EX CX.) The forces on the two carts are identical. The accelerations are the same. The energy begins as mechanical potential and changes to kinetic. The energy is divided up equally between the two carts.

EX CY.) The fuel hits the sides, and there is a force on each side out. Opposite sides cancel, except there is no side to cancel the force on the front. The fuel goes out, the casing goes forward.

EX CY.) The astronaut acts on the ball (to the right) causing a negative acceleration, which slows the ball down. The ball acts on the astronaut (to the left) causing the astronaut to speed up.

EX CZ.) Book acts on table, table acts on book. Gravity acts on book (book acts on earth).

EX DA.) As they speed up, the velocity increase, thus the air resistance increases. The net force decreases until it is zero. The acceleration decreases until it is zero. The velocity increases at a decreasing rate until terminal velocity.

Answers to Example Problems - Chapter 12

EX DB.) $\Delta P = 0$
$m_c v_c = m_b v_b$
$v_c = -3.69$ m/s

EX DC.) $\Delta P = 0$
$m_1 v_1 = m_{1+2} v_{1+2}$
$v_{1+2} = 3.1$ m/s

EX DD.) $\Delta P = 0$
$P_{before} = P_{after}$
$0 = m_c v_c + (m_b + m_{rr} - m_c) v$
$v = 0.1$ m/s

$\Delta P = 0$
$P_b = P_a$
$0 = m_{c2} v_{c2} + m_c v_c + (m_b + m_{rr} - m_c) v$
$0 = (100)(1.9) + (100)(2) + (1900) v$
$v = 0.205$ m/s

EX DE.) a.)
b.) equal but opposite
c.) equal but opposite impulses
d.) same
e.) not equal, inconclusive information
f.) they must come to a stop to satisfy $\Delta P=0$

EX DF.) $\Delta P = 0$
$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$
$48 - 15 = (13) v$
$v = 2.5$ m/s (note: positive)

EX DG.) $\Delta P = 0$
$m_1 v_1 + m_2 v_2 = m_1 v_{1f} + m_2 v_{2f}$
$64 - 20 = (8) v_{1f} + 15$
$v_{1f} = 3.6$ m/s

EX DH.) $\Delta P = 0$
$m v_i = m v_f + m v_{f2}$
$v_i = v_f + v_{f2}$ eq. 1

$\Delta T = 0$
$v_i^2 = v_f^2 + v_{f2}^2$
$v_i^2 = (v_i - v_{f2})^2 + v_{f2}^2$ using eq. 1
.....
$v_{f2} = v_i$

thus $v_f = 0$

EX DI.) by switching into a frame where $v_2 = 0$, the other velocity becomes $v_1 + v_2$. Applying the previous result, and switching back out gives:

$v_{1f} = v_2$
$v_{2f} = v_1$

EX DJ.) $\Delta P = 0$
$m_1v_1 = m_1v_{f1} + m_2v_{f2}$
$m_1(v_1 - v_{f1}) = m_2v_{f2}$

$\Delta T = 0$
$m_1v_1^2 - m_1v_{f1}^2 = m_2v_{f2}^2$
$m_1(v_1 - v_{f1})(v_1 + v_{f1}) = m_2v_{f2}^2$

algebraic juggling.....

EX DK.) v_{1f} = -4.4 m/s goes to -13.6 m/s
v_{2f} = 11.6 m/s goes to 2.6 m/s

EX DL.) a.) $v_1 = 0$
$v_2 = v_1$

b.) $v_1 = -v_1$
$v_2 = 0$

c.) $v_1 = v_1$
$v_2 = 2v_1$

EX DM.) Just before they hit the ground, there is a little space between them. After the basket ball bounces, we have a collision between a large and small object each approaching each other at v. Solving the collision by switching reference frames and using extreme cases gives us the tennis ball going up at 3v. Thus it goes up to 9x the original height.

EX DN.) $\Delta P_x = 0$
$mv_1\cos50^\circ + mv_2\cos40^\circ = 32 + 48\cos45^\circ$
$(2.57)v_1 + (3.06)v_2 = 65.94$

$\Delta P_y = 0$
$mv_1\sin50^\circ - mv_2\sin40^\circ = 33.94$
$(3.06)v_1 - (2.57)v_2 = 33.94$

v_1 = 17.09 m/s
v_2 = 7.18 m/s

EX DO.) $P_x = 6$, v_x = 0.86 m/s
$P_y = 20$, $v_y = 2.86$

v = 2.98 m/s
$\theta = \arctan(2.86/0.86) = 73^0$

EX DP.)

EX DQ.) Considering momentum before and after the fan is turned on, since after the fan is operational, there is momentum to the left (the moving air after hitting the sail), there must be momentum to the right (the moving fan cart). Thus the cart moves to the right.

The force on the sail is greater because the air must bounce, not just be moved.

EX DR.) Two throws. On the first throw, the astronaut would go off to the left at the same velocity as the ball. After the catch, the astronaut would go off to the right at (1/2)v. After throwing the ball to the left at v, the ball would only be going (1/2)v to the left and would never catch up to the first astronaut.

Answers to Example Problems - Chapter 13

EX DS.)

EX DT.) Varies by experiment.

EX DU.)
$\Sigma F_y = 0$
$T_y - mg = 0$
$T = mg/\sin 40°$
$T = 45.7$ N

$\Sigma F_x = 0$
$R - T_x = 0$
$R = T\cos 40°$
$R = 35$ N

EX DV.)
$\Sigma F_x = 0$
$mg\sin 35° = k\Delta x$
$\Delta x = 0.056$ m

$\Sigma F_y = 0$
$N = mg\cos 35°$
$N = 24$ N

EX DW.)
$\Sigma F_x = 0$
$B = A + W$
$W = 500$ N

$P = F/A$
$P = 1667$ Pa

EX DX.) with axes along face and perpendicular to kite:
$\Sigma F_x = 0$
$mg\cos 60° - T\cos 75° + W_x = 0$
$W_x = 5.3$ N

$\Sigma F_y = 0$
$-mg\sin 60° - T\sin 75° + W_y = 0$
$W_y = 33.2$ N

w = 33.6 N at 81° to kites face

EX DY.)
a.) $mg + ma = 768$ N
b.) $mg - ma = 408$ N
c.) $mg = 588$ N

EX DZ.) $\Sigma F_x = ma$

$mg\sin\theta = ma$

$a = g\sin\theta$

$\Delta x = v_i t + (.5)at^2$

$t = sqr(2\Delta x/g\sin\theta)$

EX EA.) on block A:

$m_a g - T = m_a a$

on block B:

$T - m_b g = m_b a$

isolate T in each and set equal:

$m_a g - m_a a = m_b a - m_b g$

solve:

$a = g(m_a - m_b)/(m_a + m_b)$

put in numbers:

$a = 3.77\ m/s^2$

$T = 54.3\ N$

EX EB.) $m_a = m_b \Rightarrow a = 0$

$m_a >> m_b \Rightarrow a = g$

$m_b >> m_a \Rightarrow a = -g$

EX EC.) many ways to do this:

look first at entire system:

$\Sigma F = ma$

$30\ N = (9\ kg)a$

$a = 3.33\ m/s^2$

now look only at second block:

$\Sigma F = ma$

$T = (2\ kg)(3.33\ m/s^2)$

$T = 6.67\ N$

Answers to Example Problems - Chapter 14

EX EF.) $F_f = 3$ N
$\mu = .3$

the force of friction and thus the coefficient

EX EG.) $F_f = \mu N$
$F_f = 14.5$ N

EX EH.) $\Sigma F = 0$
$P - \mu N = 0$
$100 \text{ N} - (0.46)(30 \text{ kg})(9.8 \text{ m/s}^2) = 0$
$100 \text{ N} - 135 \text{ N} = ?$
it won't move

$\Sigma F = ma$
$150 \text{ N} - 135 \text{ N} = (30 \text{ kg})a$
$a = 0.5$ (but this is wrong!)

EX EI.) $N = mg\cos 36°$
$N = 127$ N

$mg\sin 36° - \mu N = 0$
$\mu = 0.73$

EX EJ.) $mg\sin\theta - \mu mg\cos\theta = 0$
$\sin\theta - \mu\cos\theta = 0$
$\mu = \tan\theta$

EX EK.) $N = F_{mag}$
$N = 2.0$ N

$mg - F_f = ?$
$mg - \mu N = ?$
$0.735 \text{ N} - 0.8 \text{ N} = ?$
$-0.065 \text{ N} = ?$
thus it will stick

EX EL.) a.) $\Sigma F_x = ?$
$F - \mu mg = ?$
$80 \text{ N} - 78.4 \text{ N} = ?$
thus it moves

b.) $F - \mu mg = ma$
$a = 1.1 \text{ m/s}^2$

c.) $v_f = v_i + at$
$v_f = 17$ m/s

d.) $\Sigma F = ma$
$-F_f = ma$
$-\mu mg = ma$
$a = -2.94\ m/s^2$

$v_f = v_i + at$
$t = 5.78\ sec$

EX EM.) first find normal:
$N = mg + F\sin\theta$
$N = 788\ N$

$\Sigma F = ma$
$F_x - F_f = ma$
$F\cos\theta - \mu_k N = ma$
$a = 3.15\ m/s^2$

EX EN.) on block A:
$T = mg$
$T = 29.4\ N$

on block B:
$N = mg\cos\theta$

$\Sigma F_x = 0$
$T + mg_x - F_f = 0$
$T + mg\sin\theta - \mu N = 0$
$m = 13.5\ kg$

or: $W = 132.5\ N$

EX EO.)

Answers to Example Problems - Chapter 15

EX EP.) $a = v^2/r = 4\ m/s^2$
$F = ma = 2\ N$
the tension

EX EQ.) $v = 4*2\pi r/t = 16.75\ m/s$
$F = mv^2/r = 70.1\ N$

EX ER.) $\Sigma F = ma_c$
$F_f = mv^2/r$
$\mu mg = mv^2/r$
$\mu = v^2/rg = \omega^2 r/g = 0.12$

EX ES.) same derivation as above:
$\mu g = v^2/r$
$v = (\mu gr)^{1/2}$
$v = 15.5\ m/s$

EX ET.) in the r-direction (horizontal to the ground)
$\Sigma F = ma_c$
$N\sin\theta + F_f\cos\theta = mv^2/r$
$N(\sin\theta + \mu\cos\theta) = mv^2/r$

in the z-direction we get:
$N\cos\theta - mg - F_f\sin\theta = 0$
$N(\cos\theta - \mu\sin\theta) = mg$

combining gives result on next page

EX EU.)

EX EV.)

EX EW.) $W = mv^2/r$
$g = v^2/r$
$v = (gr)^{1/2}$
$v = 3.1\ m/s$

EX EX.) $\Sigma F = mv^2/r$
$N + mg = mv^2/r$

$N = mv^2/r - mg = 9010$ N (the supports holding the track)

Answers to Example Problems - Chapter 16

EX EY.) $T_1 = F_1 d = 12$ Nm
$T_2 = F_2 d = 20$ Nm

EX EZ.) $T = Fd = Fd\sin 40^\circ = 96.3$ Nm

EX EF.) zero

EX EG.) $\Sigma T = T_{ccw} - T_{cw}$
$= Pd\sin 65^\circ - mgd_{cm}$
$= (6\text{ N})(1\text{ m})\sin 65^\circ - (3\text{ N})(0.4\text{ m}) = 4.23$ Nm

EX EH.) same answer but use $(P\sin 65^\circ)d$ instead of $Pd\sin 65^\circ$

EX FD.) $\Sigma T = 0$ (with pivot point at fulcrum)
$mgd_1 - Pd_2 = 0$
$(30\text{ kg})(9.8\text{ m/s}^2)(2.1\text{ m}) - P(1.4\text{ m}) = 0$
$P = 441$ N

$\Sigma T = 0$ (with pivot at mass)
$Nd_1 - Pd_2 = 0$
$N(2.1\text{ m}) - (441\text{ N})(3.5\text{ m}) = 0$
$N = 735$ N
(or use $\Sigma F_y = 0$)

EX FE.) $\Sigma T = 0$ (with pivot at wall)
$T_T - T_{mg} - T_{sign} = 0$
$T(d\sin 30^\circ) - mgd_2 - mgd_3 = 0$
$T(1.3\text{ m})\sin 30^\circ - (20\text{ N})(0.7\text{ m}) - (60\text{ N})(1.1\text{ m}) = 0$
$T = 123$ N

EX FF.) $\Sigma T = 0$ (with pivot at scale B)
$mgd_1 + m_2gd_2 - N_Ad_3 = 0$
$(15\text{ kg})(g)(3\text{ m}) + (10\text{ kg})(g)(2\text{ m}) - N_A(4\text{ m}) = 0$
$N_A = 160$ N

Then use $\Sigma F = 0$
$N_A + N_B - mg - m_2g = 0$
$N_B = 86$ N

EX FG.) $\Sigma T = 0$ (with pivot at point where bones meet)
$Pd_1 - Cd_2 = 0$
$C = 1764$ N (3x your weight)

<u>Answers to Example Problems - Chapter 17</u>

EX B.) A.) $I = mr^2/2$

$\Sigma T = I\alpha$

$Fr = (mr^2/2)(1.5\ r/s)$

$F = 0.225\ N$

B.) $I = mr^2/4 + mL^2/12$

$F = I\alpha/r$

$F = (0.079)\alpha$

$F = 0.1185\ N$

EX C.) $\Sigma T = I\alpha$

$F_f r = I\alpha$

$\alpha = F_f r/I$

$\Sigma F = ma$

$mg\sin\theta - F_f = ma$

$mg\sin\theta - I\alpha/r = ma$

$mg\sin\theta - Ia/r^2 = ma$

$(g\sin\theta)/(1+I/mr^2) = a$

$\alpha = (g\sin\theta)/(r+I/mr)$

For disk $\alpha = 2g\sin\theta/3r$

For hoop $\alpha = g\sin\theta/2r$

For sphere $\alpha = 5g\sin\theta/7r$

EX D.) $\Delta d = r\Delta\theta$

$\Delta\theta = d/r$

$\Delta\theta = (1/2)\alpha t$

$\Delta d/r = (1/2)(5g\sin\theta)(t^2)/(7r)$

$t = sqr((14d)/(5g\sin\theta))$

EX E.) $\Sigma T = I\alpha$

$Tr =(mr^2/2)\alpha$

$T = m_p a/2$

$\Sigma F = ma$

$m_b g - T = m_b a$

$m_b g - m_p a/2 = m_b a$

$a = (m_b g)/(m_b + m_p 2) = 7.84\ m/s^2$

$T = 7.84\ N$

EX F.) For solid ball

$T_i = T_f + \Delta U$
$0 = (1/2)mv^2 + (1/2)I\omega^2 - mgh$
$0 = (1/2)mv^2 + (1/2)Iv^2/r^2 - mgh$
$0 = (1/2)mv^2 + (1/2)(2/5)mv^2 - mgh$
$0 = (7/5)v^2 - gh$
$v = sqr(5gh/7) = 1.87$ m/s

EX G.) From ΣF we get $T_2 = m_2g - m_2a$ and $T_1 = m_1a + m_1g$
thus $T_1 - T_2 = m_1a + m_2a + (m_1 - m_2)g$

$\Sigma T = I\alpha$
$T_2r - T_1r = (2/5)mr^2\alpha$
$T_2 - T_1 = (2/5)ma$

$-(2/5)ma = m_1a + m_2a + (m_1 - m_2)g$
$a = (m_2 - m_1)g/(2m/5 + m_1 + m_2)$

EX H.) A.) w/o flywheel : $T_i = T_f + \Delta U$
$T = mgh = 5$ J
but block actually has 3 J
thus flywheel has 2 J
B.) $v_f^2 = v_i^2 + 2a\Delta x$
$a = 0.36$ m/s^2
C.) $\alpha = a/r = 3.6$ r/s^2
D.) $\omega = v/r = 12$ r/s
E.) $T_r = (1/2)I\omega^2$
$I = mr^2/2$
$(2 \text{ J}) = (1/2)m(0.1)^2(12)^2/2$
$m = 5.56$ kg

EX L.) $L_b = L_a$
$I_1\omega_1 = (I_1 + I_2)\omega_2$
$m_1r_1^2\omega_1/2 = (m_1r_1^2/2 + m_2r_2^2/2)\omega_2$
$0.2 = (0.13)\omega_2$
$\omega_2 = 1.53$ r/s

EX M.) $L_b = L_a$
$I_1\omega_1 = I_1\omega_f + m_2v_tr^2$
$10mr^2/2 = mr^2\omega_f/2 + m_2\omega_fr^2$
$0.9375 = (0.125)\omega_f$
$\omega_f = 7.5$ r/s

Answers to Example Problems - Chapter 18

Ex GGT.)

A.) 0.25 s
B.) 4 Hz
C.) $\omega = 8\pi$ r/s = 25.1 r/s
D.) 196 kg/s^2
E.) $V_m = \omega x_m$ = 2.51 m/s
F.) $F = k\Delta x$ = 19.6 N
G.) (0.1 m)cos((25.1)t + π/2)
H.) 0.0023 m

EX TRT.)

$\omega = 2\pi/T$ = 31.41 r/s

a.) Y(t) = (0.08 m)cos(31.4t+φ)
-0.45 = cosφ
φ = 2.04 rad

Y(t) = (0.08 m)cos(31.4t + 2.04)

b.) V(t) = -(2.51 m/s)sin(31.4t + 2.04)

c.) A(t) = -(78.8 m/s^2)cos(31.4t + 2/04)

EX EZZZ.)

$\omega^2 = g/L$
ω = 3.13 r/s

$\varphi = 0$

A.) Y = (0.1)cos(3.13t)
Y = -0.063 m

B.) V = -(0313)sin(3.13t)
V = -0.24 m/s

C.) A = -(0.979)cos(3.13t)
A = 0.62 m/s^2

Answers to Example Problems - Chapter 19

EX R.) Work you do: $W= Fd = 240$ J
Work gravity does: -210 J

EX S.) $W = Fd\cos\theta = -200$ J
$W = Fd\cos\theta = 350$ J

EX T.) A.) $W = Fd\cos\theta = 1x10^6$ J
b.) 0 J
c.) $-6x10^5$ J
d.) $4x10^5$ J
e.) $-1x10^6$ J
f.) $F_{net} = 4000$ N = ma
$a = 2 \ \ m/s^2$

$v_f^2 = v_i^2 + 2a\Delta x$
$v_f^2 = 400\ m^2/s^2$

$(1/2)mv^2 = 4x10^5$ J

EX T.) $W = \Delta T$
$W = (1/2)mv^2 = -1.3x10^{18}$ J

$W = Fd$
$F = 7.1x10^{15}$ N

EX U.)
A.) $T_i = T_f + \Delta U$
$T_f = -mgh = (60\ kg)(9.8)(9\ m) = 5292$ J

$W = \Delta T = -5292$ J
(Note: this does not include the change in potential for the last half meter)

B.) $W = Fd$
$F = 10584$ N

c.) $T = mgh$
$v = sqr(2gh) = 12.5$ m/s

EX W.)
$T_i = T_f + \Delta U - W$
$0 = (1/2)mv^2 + mgh - Fd$
$0 = (1/2)(800)v^2 + (800\ kg)(9.8\ m/s)(500m)\sin(35^o) - (10,000\ N)(500\ m)$
$v = 83$ m/s

EX REEE.) $W_{ap} = 0$ J

$W_{pq} = 150$ J
$W_{qr} = -510$ J
$W_{rs} = 552$ J
$W_{sb} = -490$ J

$W = -298$ J

Answers to Example Problems - Chapter 20

EX B.) $F = Gm_1m_2/r^2$

$= (6.67\text{x}10^{-11})(5.98 \text{ x } 10^{24} \text{ kg})(7.36 \text{ x } 10^{22} \text{ kg})/(3.8\text{x}10^8 \text{ m})^2$

$= 2.0 \text{ x } 10^{20} \text{ N}$

EX C.) a.) $r^2 = Gm/g$

$r = 6.3787 \text{ x } 10^6 \text{ m}$

b.) $r = 6.385 \text{ x } 10^6 \text{ m}$

EX D.) $g = Gm/r^2$

$= (6.67 \text{ x } 10^{-11})(1.9\text{x}10^{27} \text{ kg})/(7.15\text{x}10^7 \text{ m})^2$

$= 24.8 \text{ m/s}^2$

$F = mg = 1736 \text{ N}$

$10 \text{ m} = (1/2)(24.8 \text{ m/s}^2)t^2$

t = 0.9 se (earth = 1.4 sec)

EX OOPP.) $g_1 = 1.62 \text{ x } 10^{-5} \text{ m/sec}^2$

$g_{1x} = -8.1 \text{ x } 10^{-6}$

$g_{1y} = 1.4 \text{ x } 10^{-5}$

$g_2 = 1.63 \text{ x } 10^{-5} \text{ m/sec}^2$

$g_{2x} = 1.34 \text{ x } 10^{-5}$

$g_{2y} = 9.35 \text{ x } 10^{-6}$

$g_x = g_{2x} - g_{1x} = 5.25 \text{ x } 10^{-6} \text{ m/sec}^2$

$g_y = g_{1y} + g_{2y} = 2.33 \text{ x } 10^{-5}$

$g = 2.39 \text{ x } 10^{-5} \text{ m/sec}^2$

$\theta = -77°$

EX OOPQ.) $U = Gm_em_s/r^2$

$U = G(5.98\text{x}10^{24} \text{ kg})(50000 \text{ kg})/(6.385\text{x}10^6 \text{ m} + 482804 \text{ m})$

$U = 2.90 \text{ x } 10^{12} \text{ J}$

EX E.) $v^2 = 2Gm_e/r$

$= 2G(5.98\text{x}10^{24} \text{ kg})/(6.37\text{x}10^6 \text{ m})$

$v = 1.12 \text{ x } 10^4$ m/sec (25,000 mph)

EX OOPR.) the energy at a 300 mile orbit was calculated.

at 400 miles:

$U_{400} = G(5.98\text{x}10^{24} \text{ kg})(50000 \text{ kg})/(6.385\text{x}10^6 + 643800 \text{ m})^2$

$U_{400} = 2.84 \text{ x } 10^{12} \text{ J}$

$\Delta U = 6.0 \text{ x } 10^{10} \text{ J}$

To put the shuttle in place, you needed to go from the surface to the orbit

$U_{surface} = G(5.98x10^{24})(50000)/(6.38x10^{6}\ m)$
$U_s = 3.13 \times 10^{12}$ J

$\Delta U = 2.26 \times 10^{11}$ J