Manual of General Physics : HW2

4.11

(a) By Newton's 2nd law for a constant mass(m),

$$\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} = m\frac{d^2\vec{r}}{dt^2} \tag{1}$$

In the question, electron's speed is changed by certain constant acceleration from $3.00 * 10^5 m/s$ to $7.00 * 10^5 m/s$ in a distance of 5.00cm. Therefore, we can just consider magnitude of eq.1. By integration of eq.1, we can obtain

$$v(t) = at + v(0) \Rightarrow r(t) = r(0) + v(0)t + \frac{at^2}{2} \tag{2}$$

Set initial point($r(0)$) is zero. Then, eq.2 turns quadratic equation when $r(t_f) = 0.05m$.

$$at_f^2 + 2v(0)t_f - 0.1 = 0 \tag{3}$$

From eq.2, we can write acceleration(a) with $v(t_f) = 7.00 * 10^5 m/s$ and $v(0) = 3.00 * 10^5 m/s$

$$a = \frac{v(t_f) - v(0)}{t_f} \tag{4}$$

Then, eq.3 turns linear equation

$$(v(t_f) + v(0))t_f = 0.1 \Rightarrow t_f = 1.00 * 10^{-7} s \tag{5}$$

So, from eq.4, we can obtain acceleration

$$a = 4.00 * 10^{12} m/s^2 \Rightarrow \left|\vec{F}\right| = ma = 3.64 * 10^{-18} N \tag{6}$$

(b) the weight of electron on the surface of earth(where gravitational acceleration = $9.8m/s^2$) is

$$\left|\vec{F_w}\right| = 8.93 * 10^{-30} N \tag{7}$$

The ratio between weight and force getting on (a) is

$$\frac{|F|}{|F_w|} = 4.08 * 10^{11} \tag{8}$$

It means that we can ignore the weight of electron when we consider force($\vec{F}$)

4.12

Man's weight is $900N$ in the surface of the earth. We can describe this by equation like

$$\left|\vec{F_{we}}\right| = mg_e \tag{9}$$

where m is man's mass and g_e is the gravitational acceleration in the surface of the earth. Next, when we consiger on the surface of Jupiter, then the only gravitational acceleration changes and it makes different weight.

$$\left|\vec{F_{wj}}\right| = mg_j = \left|\vec{F_{we}}\right| \frac{g_j}{g_e} \tag{10}$$

where $g_j = 25.9m/s^2$ is Jupiter's gravitational acceleration. Therefore, the weight of man on the Jupiter is

$$\left|\vec{F_{wj}}\right| = 900 * \frac{25.9}{9.8} = 2.38 * 10^3 N \tag{11}$$

4.22

(a) Gravitational force exerts on each balls with the same magnitude($49.0N$) $\Rightarrow 49.0N$
(b) Just one ball changes with the wall and ,if the wall does not move, the wall exerts on the same force like (a). $\Rightarrow 49.0N$
(c) Since gravitational forces have the same direction, the magnitude of net force is $\Rightarrow 98.0N$
(d) In this case, there are two kinds of force; gravitational force and normal force by the slope. We can divide gravitational force along the slope and then normal force is cancelled. There is only $mg \sin 30.0° \Rightarrow 24.5N$

4.26

(a) We can divide T_1 and T_2 in the two dimensional cartesian coordinate as the direction of T_3 is the $-\hat{j}$. Next, when the elevator is moving with constant velocity, it means that the net force in the elevator is zero. So,

$$T_3 = T_2 \sin 50.0° + T_1 \sin 40.0° \tag{12}$$

$$T_1 \cos 40.0° = T_2 \cos 50.0° = T_2 \sin 40.0° \tag{13}$$

$$T_3 = T_2(\sin 50.0° + \tan 40.0° \sin 40.0°) \tag{14}$$

and by gravitational force $T_3 = 49.0N$. Therefore,

$$T_2 = 37.5N \Rightarrow T_1 = 31.5N \tag{15}$$

(b) Also, we can obtain the tension after the same steps with (a).

$$T_3 = T_1 \sin 60.0° \tag{16}$$

$$T_1 \cos 60.0° = T_2 \tag{17}$$

In this case, the mass of ball is $10.0kg$ and the weight of ball is $98.0N$. So, the $T_3 = 98.0N$.

$$T_1 = 113.N \;\; T_2 = 56.6N \tag{18}$$

4.30

(a)Draw a free-body diagram
(b) Since the acceleration(a) of m_1 and m_2 is the same,

$$(m_1 + m_2)a = m_1 g - m_2 g \sin\theta \tag{19}$$

$$a = \left| \frac{m_1 g - m_2 g \sin\theta}{m_1 + m_2} \right| = 3.57 m/s^2 \tag{20}$$

(c) By the free-body diagram,

$$m_1 a = T - m_1 g \Rightarrow T = m_1 (g + \frac{m_1 g - m_2 g \sin\theta}{m_1 + m_2}) = \frac{m_1 m_2 g}{m_1 + m_2}(1 + \sin\theta) = 26.74N \tag{21}$$

(d) As the acceleration(a) is independent on the time, the speed($v(t = 2.00s)$) from rest is

$$v(t) = at \Rightarrow v(2) = 2a = 2 \left| \frac{m_1 g - m_2 g \sin\theta}{m_1 + m_2} \right| = 7.14 m/s^2 \tag{22}$$

4.55

By the Newton's 2nd law for a constant mass(m)

$$\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} \tag{23}$$

This equation approximatly can be expressed

$$\frac{\vec{F}}{m} = \frac{\Delta\vec{v}}{\Delta t} \tag{24}$$

When the man arrive the floor with speed(v) vertically, we can calculate this v from rest

$$v = g t_f, h = 1 - \frac{g t_f^2}{2} \Rightarrow t_f = \sqrt{\frac{2}{g}}, v = \sqrt{2g} \tag{25}$$

where t_f is the time when the man arrive the floot and h is the distance from the floor. To stop the man, there is a certain force exerting on the man. We call this force F_s and set this constant force only exerts along the very small distance d. Then,

$$\frac{F_s}{m} = a \Rightarrow \begin{cases} d = v(0)t - \frac{at^2}{2} \\ at = v(0) \end{cases} \Rightarrow t = \frac{2d}{\sqrt{2g}} \tag{26}$$

Therefore, certain force changes the speed from $\sqrt{2g}$ to 0 during $t = \frac{2d}{\sqrt{2g}}$. By eq.24, we can describe F_s

$$F_s = m\frac{g}{d} < 5.12 * 10^4 N \tag{27}$$

When m is $60.0kg$

$$d > 1.15cm \tag{28}$$

5.13

(a) Draw a free-body diagram

(b)When each blocks have the same kinetic friction coefficient(μ), 0.1, their frictional forces(f) is the multiplication of coefficient and normal force(N)

$$f = \mu N = \mu(12.0 + 18.0)g \tag{29}$$

where g is the gravitational acceleration. Since the acceleration(a) of m_1 and m_2 is the same,

$$F = 68.0N = (m_1 + m_2)a + 29.4 \Rightarrow a = 1.29m/s^2 \tag{30}$$

(c) What a force making m_1 be able to move is tension. Therefore, tension(T) is

$$T = m_1 a + \mu N_{m1} = 27.2N \tag{31}$$

5.20

(a) When a particle moves in a constant circular motion, the centripetal force can be expressed

$$F = m_e \frac{v^2}{r} \Rightarrow 8.32 * 10^{-8} N \tag{32}$$

where $r = 0.530*10^{-10}m$ is radius, $v = 2.20*10^6 m/s$ is the speed and $m_e = 9.11*10^{-31}kg$ is the mass of electron.
(b) the accerelation(a) is

$$a = \frac{F}{m_e} = \frac{v^2}{r} = 9.13 * 10^{22} m/s^2 \tag{33}$$

5.21

(a) Verical force(F_v) is gravitational force and horizontal force(F_h) is centripetal force. Tension on the string cancels these forces.

$$\begin{cases} F_v = mg \\ F_h = m\frac{v^2}{r} \end{cases} \Rightarrow \begin{cases} mg = T\cos\theta = 784.0N \\ m\frac{v^2}{r} = T\sin\theta = 68.59N \end{cases} \tag{34}$$

(b) From eq.33, we can obtatin radial accerelation($a = \frac{v^2}{r}$)

$$\frac{v^2}{r} = g\tan\theta = 0.86m/s^2 \tag{35}$$

5.46

(a) In the diagram, copper take the gravitational force parallel to the slope. If the copper and aluminium move, it satisfies

$$m_2 g \sin 30.0° - m_2 g \cos 30.0° \mu_s(copper) - m_1 g \mu_s(aluminium) > 0 \tag{36}$$

where each frictional coefficient is the maximum values. However, the left side of eq.35 is $-0.91N$. It is not moving

(b) & (c) skip (not move)

(d) When the copper and aluminium are not moving, the sum of frictional force is the same with the $m_2 g \sin 30.0° = 29.4N$

5.51

"Artificial gravity" is made by normal force of the centripetal force when spaceship rotating.Therefore,

$$3.00m/s^2 = \frac{v^2}{r} = r(\frac{2\pi}{T})^2 \tag{37}$$

where T is period.

$$T = 2\pi\sqrt{\frac{r}{3}} \tag{38}$$

Then, the rate of the wheel's rotation in revolutions per minute is

$$f = \frac{60}{T} = \frac{30}{\pi}\sqrt{\frac{3}{r}} = 2.14\, rev/min \tag{39}$$

5.60

(a) When the cylinder rotate with speed(v), normal force(F_n) by the centripetal force is

$$F_n = m\frac{v^2}{r} \tag{40}$$

By this normal force, there is frictional force(F_f) with frictional coefficient(μ_s) and the opposite direction of gravitational force, and then, if person do not fall down, frictional force and gravitational force is the same.

$$mg = m\frac{v^2}{r}\mu_s = m\mu_s\frac{4\pi^2 R}{T^2} \tag{41}$$

where R is the radius of the cylinder and T is the period. Then, maximum period is

$$T = (4\pi^2 R\mu_s/g)^{1/2} \tag{42}$$

(b) When the rate of revolution is larger, frictional force still works. So, frictional coefficient will be smaller.

(c) When the rate of revolution is smaller, the normal force decreases. If the period be larger the eq.40, gravitational force be lager than frictional force and the person start to go down.