Solutions PHYS-203A (Midterm Exam 02) Fall 2020

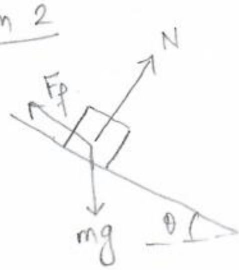
Problem 1

$$\frac{GM}{R^2} = \frac{\left(6.7\times10^{-11}\ \frac{N\,m^2}{kg^2}\right)\left(6.0\times10^{24}\ kg\right)}{\left(6.4\times10^{6}\ m\right)^2}$$

$$= 9.8\ \frac{N\,m^2}{kg^2}\,\frac{kg}{m^2} = 9.8\ \frac{m}{s^2}$$

$N = kg\,\frac{m}{s^2}$

Problem 2

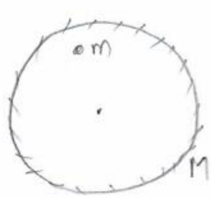


$N = mg\cos\theta$

$= (735)\cos 30$ Newtons

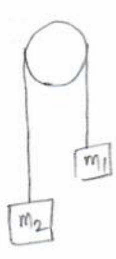
$= 637$ Newtons

Problem 3



gravitational force is zero everywhere inside.

Problem 4



If the string could extend then the masses can have different accelerations.

Problem 5

1 - Planet

2 - Earth

$$\frac{g_1}{g_2} = \frac{\left(\frac{G M_1}{R_1^2}\right)}{\left(\frac{G M_2}{R_2^2}\right)} = \left(\frac{M_1}{M_2}\right)\left(\frac{R_2}{R_1}\right)^2 = \left(\frac{1}{4}\right)\left(\frac{2}{1}\right)^2 = 1$$

$$\Rightarrow \quad g_1 = g_2 = 9.8 \ \frac{m}{s^2}$$

Problem 6

$$F_{31} = \frac{G m_3 m_1}{r_{31}^2} = \frac{(6.7\times10^{-11})(200)(300)}{(75)^2}$$

$$= 72 \times 10^{-11} \ N.$$

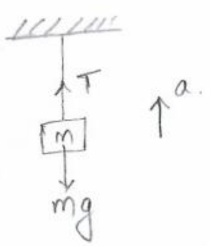
$r_{31} = r_{12} + r_{23}$
$= 75 \ m$

$$F_{32} = \frac{G m_3 m_2}{r_{23}^2} = \frac{(6.7\times10^{-11})(200)(500)}{(25)^2}$$

$$= 1072 \times 10^{-11} \ N = 1100\times10^{-11} \ N \quad \text{(if 2 sig. dig.)}$$

$$F_{tot} = F_{31} + F_{32} = 1144 \times 10^{-11} \ N = 1.1\times10^{-8} \ N$$ (towards mass 2)

Problem 7



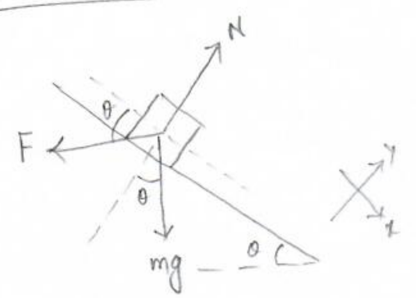
$$T - mg = ma$$

$$T = mg + ma$$

$$= (20)(9.8) + (20)(2.0)$$

$$= 240 \text{ Newtons}$$

Problem 8



$$m\vec{a} = m\vec{g} + \vec{N} + \vec{F}$$

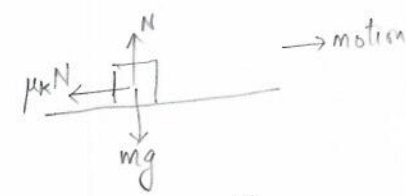
$$x: \quad 0 = mg\sin\theta + 0 - F\cos\theta$$

$$y: \quad 0 = -mg\cos\theta + N - F\sin\theta$$

x-equation implies $mg\sin\theta = F\cos\theta$

$$F = mg\tan\theta = (10)(9.8)\tan 30 = 57 \text{ Newtons}$$

Problem 9



kinetic friction acts when there is no rolling.

$$\left.\begin{array}{ll} x: & ma = -\mu_k N \\ y: & mg = N \end{array}\right\} \Rightarrow a = -\mu_k g = -(0.20)(9.8) = -2.0 \frac{m}{s^2}.$$

$\Delta x = ?$ $\quad V_i = 30.0 \frac{m}{s}$ $\quad a = -2.0 \frac{m}{s^2}$.

$\Delta t =$ $\quad V_f = 0$

$$\Delta x = \frac{V_f^2 - V_i^2}{2a} = \frac{0^2 - (30.0)^2}{2(-2.0)} = 230 \, m$$

Problem 10

$$a_c = \frac{v^2}{R}$$

$$m a_c = N - mg$$

$$N = mg + m\frac{v^2}{R}$$

$$= (75)(9.8) + 75\frac{(30.0)^2}{150}$$

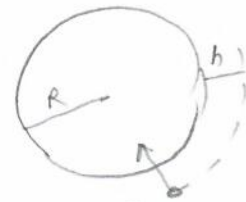
$$= 1200 \text{ Newtons}$$

Problem 11

$$\not{m}\, a_c = \frac{GM\not{m}}{(R+h)^2}$$

$r = R + h.$

$a_c = \frac{4\pi^2}{T^2} r$



$$\frac{4\pi^2}{T^2} r = \frac{GM}{r^2}$$

$r = (6.4\times 10^6 + 0.310\times 10^6)$ m

$= 6.7\times 10^6$ m

$$T = \sqrt{\frac{4\pi^2}{GM} r^3}$$

$$= \sqrt{\frac{4\pi^2 (6.7\times 10^6)^3}{(6.7\times 10^{-11})(6.0\times 10^{24})}}$$

$= 5447$ seconds $= 1.5$ hours