KEY

PHYS 1211, Fall 2012

Test #2

October 4, 2012

2:00 pm– 3:15 pm

1. ________
2. ________
3. ________
4. ________

Total ________

Name ____________________

ID ____________________

NOTE: This test consists of one set of conceptual questions and three problems. In working the problems, you <u>must show all of your calculations</u> and your reasoning clearly to receive credit. Be sure to include units in your solutions when required.

1. Conceptual questions (10 points, no calculations required). State whether the following statements are *True* or *False*.

a) The center of mass of a system consisting of two objects with masses m_1 and m_2 is closer to object 1, if $m_1 >> m_2$.

True

$$X_{cm} = \frac{m_1 X_1 + m_2 X_2}{m_1 + m_2} \xrightarrow[m_1 \gg m_2]{} X_1$$

b) A person who weights 60 pounds (about 27 kg) on the Earth would weigh 10 pounds (about 4.5 kg) on the Moon.

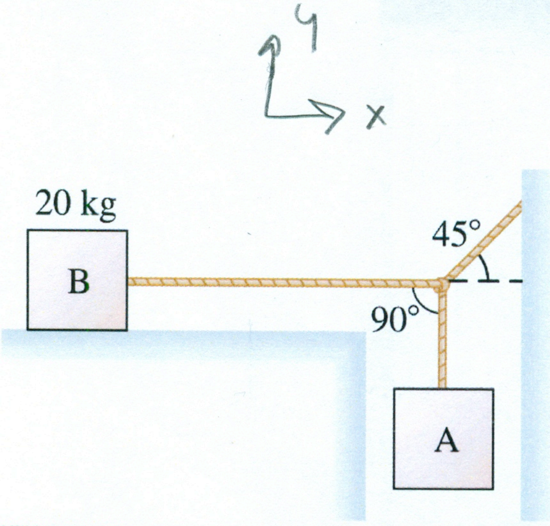
False , mass is an intrinic property of an object. It is the same every where.

c) The two forces of a Newton's 3rd law pair always act on different objects.

True , $\vec{F}_{12} = -\vec{F}_{21}$

object 1 object 2

2. In the figure, block B rests on a surface for which the static and kinetic coefficients of friction are 0.60 and 0.40, respectively. The ropes are massless. What is the maximum mass of block A for which the system is in equilibrium? (30 points)



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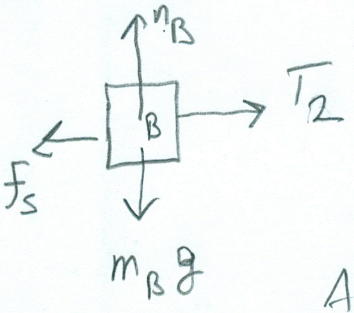
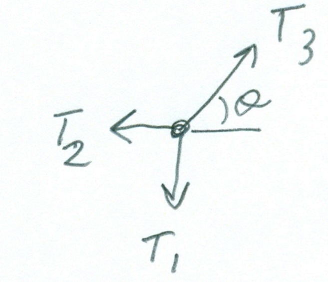
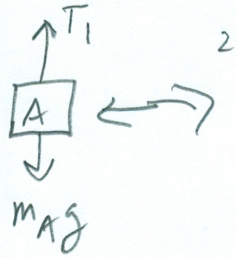
Draw FBDs







Apply Newton's 2nd Law

$\Sigma F_y = m_A a_A$

$T_1 - m_A g = 0$

if in equilibrium

$T_1 = m_A g$

Mass B will not slide for

$f_s < f_s^{max} = \mu_s n_B$

Mass B $\quad \Sigma F_y = m_B a_{yB}$

$n_B - m_B g = 0 \Rightarrow n_B = m_B g$

$\Sigma F_x = m_B a_{xB}$

$T_2 - f_s = m_B a_{xB} = 0$

$T_2 = f_s$

$T_2 = \mu_s n_B = \mu_s m_B g$

Ropes

$\Sigma F_x = 0$

$T_3 \cos\theta - T_2 = 0$

$T_2 = T_3 \cos\theta$

$\Sigma F_y = 0$

$T_3 \sin\theta - T_1 = 0$

$T_3 = \frac{T_1}{\sin\theta}$

$T_2 = \frac{T_1 \cos\theta}{\sin\theta} = \frac{m_A g}{\tan\theta}$

$\frac{m_A \cancel{g}}{\tan\theta} = \mu_s m_B \cancel{g}$

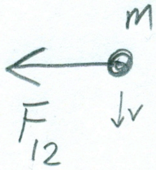
$m_A = \mu_s m_A \tan\theta$

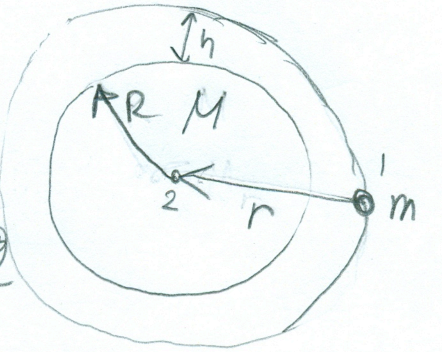
$= (0.60)(20) \tan 45° = \boxed{12 \text{ kg}}$

3. A satellite is placed in equatorial orbit above Mars, which has a radius of 3397 km and a mass of 6.40x10^{23} kg. The mission of the satellite is to observe the Martian climate from an altitude of 488 km. a) Draw a free-body diagram of the satellite assuming there is no atmospheric drag. b) If the satellite has a mass of 2000 kg, what is the magnitude of the force on the satellite due to Mars? c) What is the radial acceleration of the satellite? d) What is the orbital period and orbital speed of the satellite? (30 points)

$r = R + h = 3397 + 488 = 3885 \text{ km}$

a)





b) $$F_{12} = \frac{GMm}{r^2} = \frac{(6.67\times10^{-11})(6.4\times10^{23})(2000)}{(3885\times10^3)^2}$$

$$= 5657 = \boxed{5660 \text{ N}}$$

c) By Newton's 2nd Law

$$\Sigma F_r = m a_r$$

$$F_{12} = m a_r$$

$$a_r = \frac{F_{12}}{m} = \frac{5657 \text{ N}}{2000 \text{ kg}} = \boxed{2.83 \frac{m}{s^2}}$$

d) $$\frac{GMm}{r^2} = m a_r$$

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{(6.67\times10^{-11})(6.4\times10^{23})}{3885\times10^3}}$$

$$= \boxed{3315 \frac{m}{s}}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi r}{\sqrt{\frac{GM}{r}}}$$

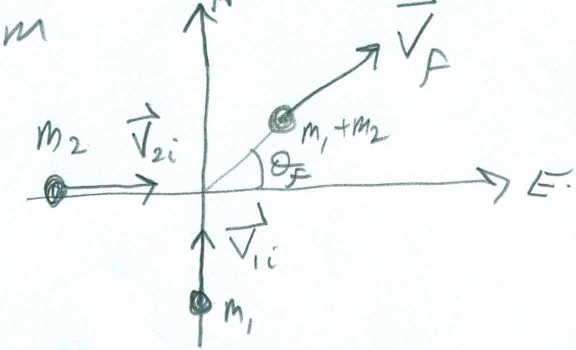
$$= \frac{2\pi r^{3/2}}{\sqrt{GM}}$$

$$= \frac{2\pi(3885\times10^3)^{3/2}}{\sqrt{(6.67\times10^{-11})(6.4\times10^{23})}}$$

$$= 7363 \text{ s} = \boxed{7360 \text{ s}}$$

m_1 m_2

4. A 2000 kg Cadillac car entered an intersection, heading north at 3.0 m/s, when it was struck by a 1000 kg eastbound Volkswagen. The cars stick together and slid, leaving skid marks angled 35° north of east. How fast was the Volkswagen going just before the impact? (30 points)



Apply conservation of linear momentum

$$\vec{P}_i = \vec{P}_f$$

$$\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$$

x: $0 + m_2 V_{2i} = (m_1 + m_2) V_f \cos\theta_f$ —(1)

y: $m_1 V_{1i} + 0 = (m_1 + m_2) V_f \sin\theta_f$ —(2)

Known:

$m_1 = 2000$ kg

$m_2 = 1000$ kg

$\vec{V}_{1i} = 3.0$ m/s $\hat{j}$

$\theta_f = 35^\circ$

unknowns

$|\vec{V}_f|$, $|\vec{V}_{2i}|$

find $|\vec{V}_{2i}| = V_{2i}$

divide (2) by (1)

$$\frac{\cancel{(m_1+m_2)}\cancel{V_f}\sin\theta_f}{\cancel{(m_1+m_2)}\cancel{V_f}\cos\theta_f} = \frac{m_1 V_{1i}}{m_2 V_{2i}}$$

$$\tan\theta_f = \frac{m_1}{m_2}\frac{V_{1i}}{V_{2i}}$$

solve for V_{2i}

$$V_{2i} = \frac{m_1}{m_2}\frac{V_{1i}}{\tan\theta_f} = \frac{\left(\frac{2000}{1000}\right)\left(3.0\frac{m}{s}\right)}{\tan 35^\circ}$$

$$V_{2i} = \boxed{8.57\frac{m}{s}}$$