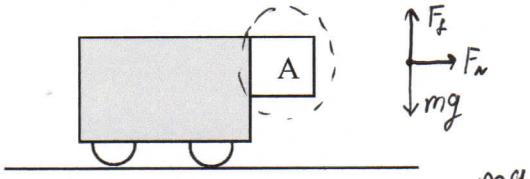
Name KEY

Review Questions
*Dynamics*

1. What acceleration must the cart shown below have in order that the block A will not fall? The coefficient of static friction between the block and the cart is $\mu_s$. How would the behavior of the block be described by an observer on the cart?

Block would look stationary




$(F_N)(\mu_s) = mg$ $\quad F_N = \frac{mg}{\mu_s}$

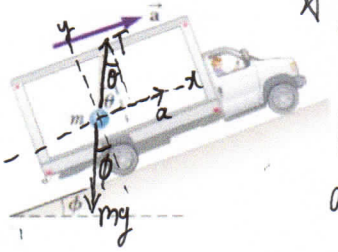
$ma = F_N$

$ma = \frac{mg}{\mu_s}$

$$a = \frac{g}{\mu_s}$$

2. A truck is moving with constant acceleration $a$ up a hill that makes an angle $\phi$ with the horizontal. A small sphere of mass $m$ is suspended from the ceiling of the truck by a light cord. If the pendulum makes a constant angle $\Theta$ with the perpendicular to the ceiling, find $a$.

Look at the truck as it it's going straight to the right (turn your paper)




★ Note the difference between $\theta$ (theta) and $\phi$ (phi).

$T\cos\theta = mg\cos\phi$

$ma = T\sin\theta - mg\sin\phi$

→ solve for T

$T = \frac{mg\cos\phi}{\cos\theta}$

Plug in to $F = ma$ equation

$ma = mg\cos\phi\tan\theta - mg\sin\phi$

$$a = g(\cos\phi\tan\theta - \sin\phi)$$

3. Two blocks with masses of 4 kg and 8 kg, respectively are connected by a sting and slide down a 30° inclined plane as shown below. The coefficient of sliding friction between the the 4 kg block and the plane is 0.25 and bewteen the 8 kg block and the plane is 0.50.

(a) Calculate the acceleration of each block.

$(8kg)(a) = (T + mg\sin 30) - F_{f1}$

$(4kg)(a) = (mg\sin 30) - (T + F_{f2})$

$(8kg)(a) = (T + 4g) - 4g\cos 30$

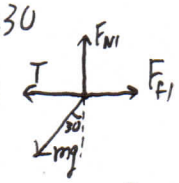
$(4kg)(a) = (2g) - (T + g\cos 30)$

$a = 1.364\ m/s^2$

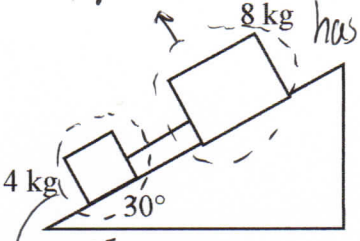
assuming $g = 9.8\ m/s^2$

$F_{N1} = mg\cos 30$

$F_{f1} = (0.5)(F_{N1})$

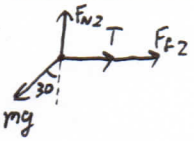



☆ Calculate acceleration of both blocks without string and the 4 kg is faster, therefore we can assume the string has tension.




$F_{N2} = mg\cos 30$

$F_{f2} = (0.25)(F_{N2})$




(b) Calculate the tension in the string.

Plug a into one of the equations

$(8kg)(1.364\ m/s^2) = (T + 4g) - 4g\cos 30$

$\boxed{T = 5.658\ N}$

4. A satellite is in a polar orbit (it passes directly above the North and South poles in its orbit). Find the height above the surface of the earth of this satellite if it passes above each pole twice a day.

$T = 1/2$ day

$m_e$ - mass of earth

$m_s$ - mass of satellite

$\frac{m_s v^2}{r} = \frac{G m_e m_s}{r^2}$

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

$v^2 = \frac{Gm_e}{r}$

$v = \frac{2\pi r}{43200}$

$\left(\frac{2\pi r}{43200}\right)^2 = \frac{Gm_e}{r}$

↳ seconds in 1/2 day

$\frac{4\pi^2 r^2}{(43200)^2} = \frac{Gm_e}{r}$

$4\pi^2 r^3 = Gm_e(43200)^2$

$\boxed{r = 26609680.17\ m}$

5. The 4-kg block is attached to vertical rod by means of two strings. When the system rotates about the axis of the rod, the strings are extended as shown in the diagram.

(a) How many revolutions per minute must the system make for the tension in the upper string to be 60 N?

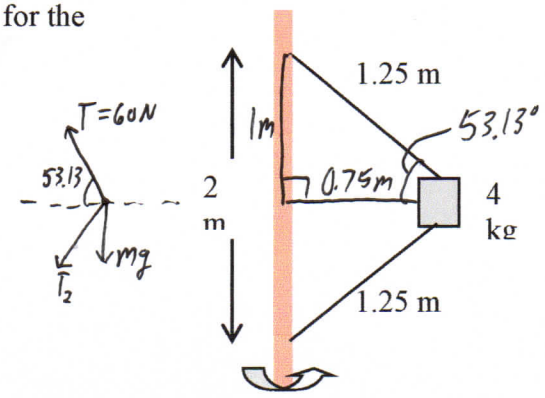
$60\sin 53.13 = T_2 \sin 53.13 + 4g$ $\quad T_2 = 11\ N$

$F_c = 60\cos 53.13 + T_2 \cos 53.13$

$\frac{4v^2}{0.75} = 60\cos 53.13 + 11\cos 53.13$

$v = 2.826\ m/s$ Convert to rpm:

**35.984 rpm**

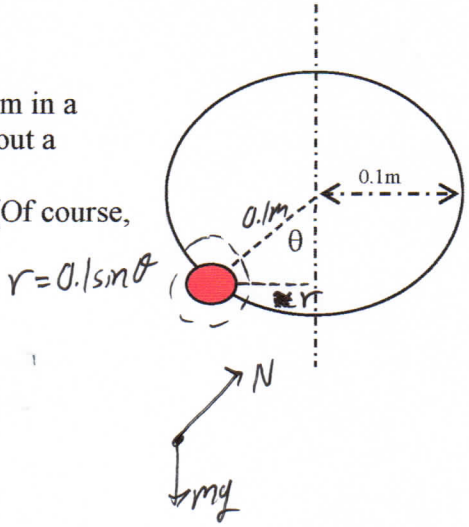



(b) What is the tension in the lower string in this case?

$T_2 = 11\ N$

6. A bead can slide without friction on a circular hoop of radius 0.1 m in a vertical plane. The hoop rotates at a constant rate of 2 rev/sec about a vertical diameter, as shown above.

(a) Find the angle θ at which the bead is in vertical equilibrium. (Of course, it has a radial acceleration toward the axis.)




$r = 0.1\sin\theta$

$N = \frac{mg}{\cos\theta}$

$\frac{mv^2}{r} = \left(\frac{mg}{\cos\theta}\right)(\sin\theta)$

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

$v = \frac{2\pi(0.1\sin\theta)}{0.5s}$

$v = 0.4\pi\sin\theta$

$\frac{(0.4\pi\sin\theta)^2}{0.1\sin\theta} = g\tan\theta$

$\frac{(0.16)(\pi^2)(\sin^2\theta)}{0.1\sin\theta} = g\tan\theta$

$15.791\sin\theta = g\tan\theta$

$1.611 = \sec\theta$ $\quad \theta = 51.64°$

$N\cos\theta = mg$

$F_c = N\sin\theta$

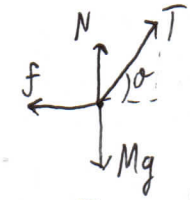
7. A block of mass 2.20 kg is accelerated across a rough surface by a light cord passing over a small pulley. The tension $T$ in the cord is maintained at 10.0 N, and the pulley is 0.100 m above the top of the block. The coefficient of kinetic friction is 0.400.

   a. Determine the acceleration of the block when x = 0.400 m.

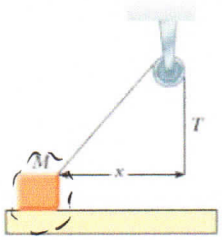
$N + T\sin(14.036) = Mg \qquad N = 19.135\,N$

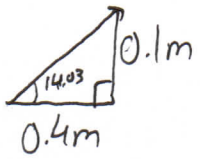
$(2.2\,kg)(a) = 10\cos 14.036 - (19.135)(0.4)$

$\boxed{a = 0.931\ m/s^2}$




$ma = T\cos\theta - f$

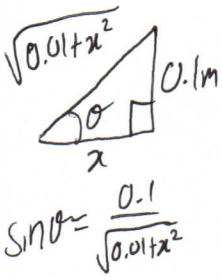



   b. Describe the general behavior of the acceleration as the block slides from a location where $x$ is large to $x = 0$.

Accel. will decrease

   c. Find the maximum value of the acceleration and the position $x$ for which it occurs.




$\sin\theta = \frac{0.1}{\sqrt{0.01+x^2}}$

$N + 10\sin\theta = Mg$

$N + \frac{1}{\sqrt{0.01+x^2}} = Mg$

$N = Mg\sqrt{0.01+x^2}$

$(M)(a) = 10\left(\frac{x}{\sqrt{0.01+x^2}}\right) - \left(Mg\sqrt{0.01+x^2}\right)(0.4)$

$a(x) = \dfrac{10x - 8.624(0.01+x^2)}{\sqrt{0.01+x^2}}$

$\boxed{a = 7.023\ m/s^2 \quad \text{at } x = 0.212\,m}$

   d. Find the value of $x$ for which the acceleration is zero.

$\boxed{x = 1.151\,m}$