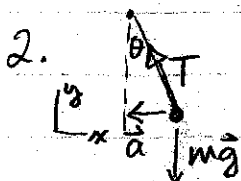


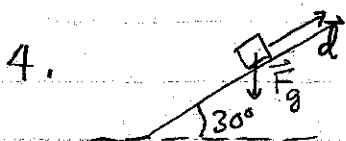
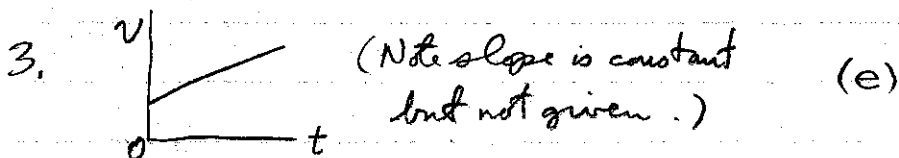
$$\sin \theta = \frac{v_w}{v_{bw}} = \frac{5 \text{ km/h}}{10 \text{ km/h}} = \frac{1}{2} \Rightarrow \theta = \sin^{-1} \frac{1}{2} = 30^\circ \text{ E of N} \quad (b)$$



$$m\vec{a} = \vec{T} + m\vec{g} \quad 0 = ma_y = T \cos \theta - mg \Rightarrow T \cos \theta = mg \quad (1)$$

$$m \left( -\frac{v^2}{r} \right) = ma_x = -T \sin \theta \Rightarrow T \sin \theta = m v^2 / r \quad (2)$$

$$\frac{(2)}{(1)} \Rightarrow \frac{v^2}{rg} = \frac{\sin \theta}{\cos \theta} \Rightarrow v = \sqrt{rg \tan \theta} = \sqrt{(60 \text{ m})(9.8 \text{ m/s}^2) \tan 16^\circ} = 13.0 \text{ m/s} \quad (c)$$



$$W = \vec{F}_g \cdot \vec{d} = mgd \cos 120^\circ = (80 \text{ N})(5.0 \text{ m})(-0.5) = -200 \text{ J} \quad (d)$$

$$m_b a_x = T - f; \quad f = \mu_k m_b g \quad \begin{cases} \uparrow T \\ \bullet m_w \\ \downarrow m_w g \end{cases} \quad \begin{matrix} \swarrow x \\ \searrow \end{matrix} \quad m_w a_x = m_w g - T$$

$$\therefore a_x = (T - \mu_k m_b g) / m_b \quad a_x = (m_w g - T) / m_w \quad (d)$$

$$6. \text{ For lamp: } 0 = ma_z = T_1 - mg \Rightarrow T_1 = mg = (42.6 \text{ kg})(9.8 \frac{\text{m}}{\text{s}^2}) = 417 \text{ N} \quad (b)$$

$$7. \text{ Forces on knot: } 0 = ma_x = F_x = -T_2 \cos 60^\circ + T_3 \cos 30^\circ \Rightarrow \frac{T_2}{T_3} = \frac{\cos 30^\circ}{\cos 60^\circ} = \frac{\sqrt{3}/2}{1/2} = \sqrt{3}$$

$$\frac{T_{2z}}{T_{3z}} = \frac{T_2 \sin 60^\circ}{T_3 \sin 30^\circ} = \sqrt{3} \frac{\sqrt{3}/2}{1/2} = 3 \quad (e)$$

$$0 = ma_x = F - mg \quad \text{where } F = -kx$$

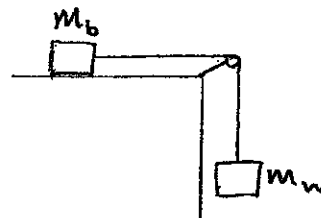
$$\therefore k = -\frac{mg}{x} = -\frac{(2.0 \text{ kg})(9.8 \text{ m/s}^2)}{(-0.06 \text{ m})} = 327 \text{ N/m}$$

$$W = \frac{1}{2} k (x_1^2 - x_2^2) = \frac{1}{2} (327 \frac{\text{N}}{\text{m}}) ((-0.06 \text{ m})^2 - (-0.16 \text{ m})^2) = -3.6 \text{ J} \quad (a)$$

1. A motor boat can travel at 10 km/h in still water. A river flows at 5 km/h west. A boater wishes to cross from the south bank to a point directly opposite on the north bank. At what angle must the boat be headed?
- a.  $27^\circ$  E of N    b.  $30^\circ$  E of N    c.  $45^\circ$  E of N    d.  $60^\circ$  E of N    e.  $63^\circ$  E of N
2. A car is moving horizontally at a constant speed around a curve which is in the shape of a circle with radius 60 m. A pendulum hangs freely inside the car. If the angle of the pendulum with respect to the vertical is  $16^\circ$ , what is the speed of the car, in m/s?
- a. 1.7    b. 4.1    c. 13    d. 17    e. 24
3. A graph of the motion of an object (moving in 1-dimension, starting from time  $t = 0$ ) is plotted with the velocity on the vertical axis and the time on the horizontal axis. The graph is a straight line. Which of these quantities CANNOT be determined from this graph?
- a. the displacement from  $t = 0$     b. the initial velocity at  $t = 0$   
 c. the acceleration of the object    d. the average velocity of the object  
 e. All four of the quantities can be determined from the graph.

4. A man pushes a crate of weight 80 N at constant speed a distance of 5.0 m up a slope that makes an angle of  $30^\circ$  with the horizontal. The work done by the force of gravity is
- a. 400 J    b. 200 J    c. -69 J    d. -200 J    e. -400 J

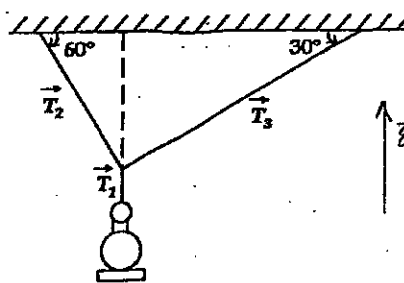
5. A block of mass  $m_b$  rests on a horizontal surface and is accelerated by means of a horizontal cord that passes over a frictionless peg to a hanging weight of mass  $m_w$ . The coefficient of kinetic friction between the block and the horizontal surface is  $\mu$  and the tension in the cord is  $T$ . The acceleration of the block is given by



- a.  $(T - m_w g)/(m_w + m_b)$   
 b.  $T/(\mu m_b g + m_b)$   
 c.  $(T - \mu m_b)/m_b$   
 d.  $(m_w g - T)/m_w$   
 e.  $T/m_b - \mu m_b g$

6. A lamp of mass 42.6 kg is hanging from wires as shown. The tension  $T_1$  in the vertical wire is

- a. 210 N  
 b. 417 N  
 c. 570 N  
 d. 360 N  
 e. 730 N



7. In the question above, the ratio of the magnitude of the vertical component of the force of tension  $\vec{T}_2$  to that of  $\vec{T}_3$ , i.e.  $|T_{2z}/T_{3z}|$ , is

- a. 1.0    b. 0.50    c. 0.58    d. 1.50    e. 3.0

8. An ideal spring is hung vertically from the ceiling. When a 2.0 kg mass hangs at rest from it, the spring is extended 6.0 cm from its unstretched length. A downward external force is now applied to the mass to extend the spring an additional 10 cm. While the spring is being extended by the force, the work done by the spring is:

- a. -3.6 J    b. -3.3 J    c.  $-3.4 \times 10^{-5}$  J    d. 3.3 J    e. 3.6 J

**PART B: ANSWER QUESTIONS 9 AND 10 IN THE SPACE PROVIDED, SHOWING ALL YOUR WORK**

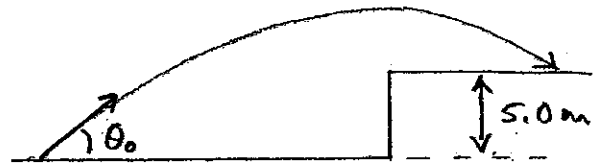
9. At time  $t = 0$ , a stone is projected at a cliff of height 5.0 m with an initial speed of 30 m/s directed at an angle  $\theta_0 = 30^\circ$  above the horizontal, as shown. (Ignore air resistance.)

- a) Find the time at which the stone lands on top of the cliff.  
b) Find the horizontal distance travelled by the stone in the air.

$$a) \quad y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$\text{where } y_0 = 0, \quad v_{0y} = v_0 \sin \theta_0$$

$$a_y = -g$$



$$\therefore y = v_{0y}t - \frac{1}{2}gt^2 \quad \text{or} \quad \frac{1}{2}gt^2 - v_{0y}t + y = 0$$

$$\therefore t = \frac{1}{2(\frac{1}{2}g)} \left( -(-v_{0y}) \pm \sqrt{(-v_{0y})^2 - 4(\frac{1}{2}g)y} \right) \quad \text{and choose + sign for the second time it passes } y=5\text{ m i.e. on way down.}$$

$$= \frac{1}{g} \left( v_{0y} + \sqrt{v_{0y}^2 - 2gy} \right)$$

$$= \frac{1}{g} \left( \frac{v_0}{2} + \sqrt{\left(\frac{v_0}{2}\right)^2 - 2gy} \right) \quad \text{using } v_{0y} = v_0 \sin 30^\circ = v_0/2 \text{ as above}$$

$$= \frac{1}{(9.8 \text{ m/s}^2)} \left( (15 \text{ m/s}) + \sqrt{\left(\frac{15 \text{ m/s}}{2}\right)^2 - 2(9.8 \frac{\text{m}}{\text{s}^2})(5.0 \text{ m})} \right) = 2.68 \text{ s}$$

$11.3 \text{ m/s}$

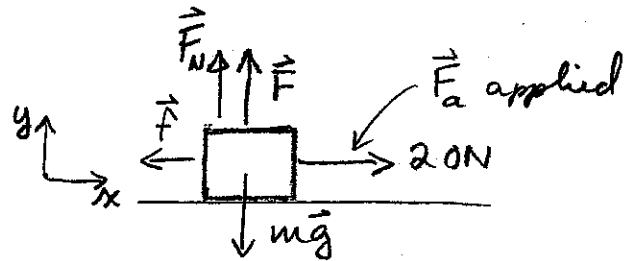
$$b) \quad x = v_{0x}t = (v_0 \cos \theta_0)t$$

$$= (30 \frac{\text{m}}{\text{s}}) \left( \underbrace{\cos 30^\circ}_{0.866} \right) (2.68 \text{ s}) = 70 \text{ m}$$

10. A box with a mass of 10 kg rests on a horizontal surface. A person pulls horizontally on it with a force of 20 N and it does not move. To start it moving, a second person pulls vertically upward on the box. If the coefficient of static friction is 0.25, find the smallest vertical force  $F$  for which the box moves.

Box moves if  $F_a > f_{\max}$  (1)  
 $|f|_{\max}$  of static friction.

where  $f_{\max} = \mu_s F_N$  (2)



$$0 = m a_y = F + F_N - mg \Rightarrow F_N = mg - F \quad (3)$$

Putting eq. (3) in (2)

$$\Rightarrow f_{\max} = \mu_s (mg - F)$$

$$\text{so eq (1)} \Rightarrow F_a > \mu_s (mg - F)$$

$$\text{i.e. } \frac{F_a}{\mu_s} - mg > -F$$

$$\therefore F > mg - \frac{F_a}{\mu_s} = (10 \text{ kg})(9.8 \frac{\text{m}}{\text{s}^2}) - \frac{20 \text{ N}}{0.25}$$

$$= 98 - 80$$

$$= 18 \text{ N}$$