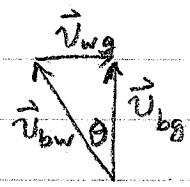

PART A: ANSWERS TO ALL MULTIPLE CHOICE QUESTIONS MUST BE INDICATED HERE

1. A particle moves on the x-axis. When its acceleration is positive and increasing:
a. its velocity must be negative b. its velocity must be positive
c. it must be speeding up d. it must be slowing down
 e. none of the above must be true
2. A motor boat can travel at 12 km/h in still water. A river flows at 6 km/h east. 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° W of N b. 30° W of N c. 45° W of N d. 60° W of N e. 63° W of N
3. At an instant when a 4.0 kg object has an acceleration equal to $(5\hat{i} + 3\hat{j})$ m/s², one of the two forces acting on the object is known to be $(12\hat{i} + 22\hat{j})$ N. The magnitude of the other force acting on the object is:
a. 2.0 N b. 1.7 N c. 18 N d. 13 N e. 6.0 N
4. A car is moving horizontally at a constant speed of 15 m/s around a curve which is in the shape of a circle with radius 200 m. A pendulum hangs freely inside the car. What is the angle of the pendulum with respect to the vertical?
a. 0.4° b. 6.5° c. 48° d. 63° e. 83°
5. A 5 kg object undergoes a displacement $\vec{d} = 2\hat{i} + 3\hat{j}$. During the displacement, a constant force $\vec{F} = 4\hat{i} - 2\hat{j}$ acts on the object. All values are given in SI units. The work done by the force \vec{F} on this object is (in J)
a. 8 b. 14 c. 2 d. -6 e. -2
6. A baseball is thrown in the air with an initial speed $v_i = 24$ m/s in a direction 30° above the horizontal. Ignore air resistance. When the ball is at the highest point in its flight,
a. its velocity and acceleration are both zero.

- b. its velocity is zero but its acceleration is nonzero.
c. its velocity is nonzero but its acceleration is zero.
 d. its velocity and acceleration are both nonzero.
e. Insufficient information is given to answer correctly.
7. If $F = 5.0$ N, what is the magnitude of the force exerted by block 2 on block 1?
 a. 17 N b. 19 N c. 21 N d. 23 N e. none of these
8. A block of mass m_1 rests on a horizontal, frictionless surface. It is attached to a spring (of force constant k) that is stretched a distance d and is attached by a horizontal cord that passes over a frictionless peg to a hanging weight of mass m_2 . The tension in the cord is T . The acceleration of the block is given by
a. $(T + kd)/m_1$
b. $(T + kd - m_2g)/(m_1 + m_2)$
c. $(m_2g - T)/m_1$
d. $g + T/m_2$
 e. $(m_2g - kd)/(m_1 + m_2)$

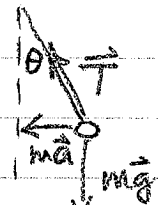
1. (e)

2.  $\vec{v}_{bg} = \vec{v}_{bw} + \vec{v}_{wg}$
 $\therefore \sin\theta = \frac{v_{wg}}{v_{bw}} = \frac{6 \text{ kph}}{12 \text{ kph}} = 0.50 \Rightarrow \theta = 30^\circ \text{ W of N}$
 (b)

3. $m\vec{a} = \vec{F}_1 + \vec{F}_2$

$\therefore \vec{F}_2 = m\vec{a} - \vec{F}_1 = (4 \text{ kg})(5\hat{i} + 3\hat{j}) \text{ m/s}^2 - (12\hat{i} + 22\hat{j}) \text{ N}$
 $= (8\hat{i} - 10\hat{j}) \text{ N}$

$\therefore |\vec{F}_2| = (8^2 + 10^2)^{1/2} = \sqrt{164} = 12.8 \text{ N}$ (d)

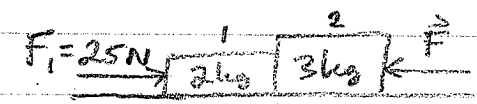
4.  $ma_r = m \frac{v^2}{r} = T \sin\theta$ $T \cos\theta = mg$
 $T = mg / \cos\theta$
 $\therefore m \frac{v^2}{r} = \frac{mg}{\cos\theta} \sin\theta$

$\therefore \tan\theta = \frac{v^2}{rg} \Rightarrow \theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{(15 \frac{\text{m}}{\text{s}})^2}{(2.0 \text{ m})(9.8 \frac{\text{m}}{\text{s}^2})}\right) = 6.5^\circ$
 (b)

5. $W = \vec{F} \cdot \vec{d} = (4\hat{i} - 2\hat{j}) \cdot (2\hat{i} + 3\hat{j}) \text{ Nm}$

$= 4 \cdot 2 + (-2) \cdot 3 = 2 \text{ J}$ (c)

6. (d)

7.  (Letting all F's be magnitudes below)
 $F_1 - F_{12} = m_1 a_1$ $F_{12} - F = m_2 a_2$

where $a_1 = a_2 \Rightarrow F_1 - F_{12} = \frac{m_1}{m_2} (F_{12} - F)$

$F_{12} = \frac{F_1 + \frac{m_1}{m_2} F}{1 + \frac{m_1}{m_2}} = \frac{25 \text{ N} + \frac{2}{3} (5 \text{ N})}{1 + \frac{2}{3}} = \frac{75 + 10}{5} = 17 \text{ N}$ (a)

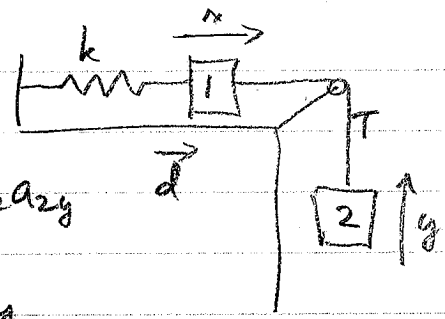
$$\delta_1 \quad m_1 a_{1x} = -kx + T \quad \text{where } x = d$$

$$m_2 a_{2y} = -m_2 g + T \Rightarrow T = m_2 g + m_2 a_{2y}$$

$$\text{Cord length constant} \Rightarrow a = a_{1x} = -a_{2y}$$

$$m_1 a = -kx + m_2 g + m_2 (-a)$$

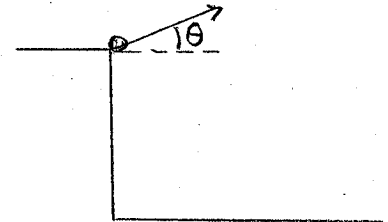
$$(m_1 + m_2) a = -kx + m_2 g \Rightarrow a = \frac{-kd + m_2 g}{m_1 + m_2} \quad (e)$$



PART B: ANSWER IN THE SPACE PROVIDED, SHOWING ALL YOUR WORK

9. At time $t = 0$, a stone is projected from the top of a cliff of height 4.0 m with an initial speed of 20 m/s directed at an angle $\theta = 15^\circ$ above the horizontal, as shown. (Ignore air resistance.)

- Find the time at which the stone lands on the (horizontal) ground underneath the cliff.
- Find the horizontal distance travelled by the stone in the air.



$$a) \quad y = y_i + v_{iy} t - \frac{1}{2} g t^2$$

$\underbrace{\hspace{10em}}_0$

$$\Rightarrow t = \frac{1}{2(-\frac{1}{2}g)} \left(-v_{iy} \pm \sqrt{v_{iy}^2 - 4(-\frac{1}{2}g)y_i} \right)$$

$$= \frac{1}{g} (v_{iy} + \sqrt{v_{iy}^2 + 2gy_i})$$

$$v_{iy} = v_i \sin 15^\circ$$

$$= (20 \frac{\text{m}}{\text{s}})(0.2598)$$

$$= 5.18 \text{ m/s}$$

$$= \frac{1}{9.8 \frac{\text{m}}{\text{s}^2}} \left(5.18 \frac{\text{m}}{\text{s}} + \sqrt{(5.18 \frac{\text{m}}{\text{s}})^2 + 2(9.8 \frac{\text{m}}{\text{s}^2})(4 \text{ m})} \right)$$

$\underbrace{\hspace{15em}}_{10.26}$

$$= 1.58 \text{ s}$$

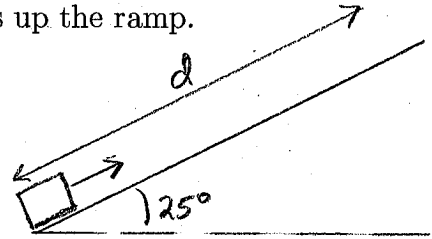
$$b) \quad x = v_{ix} t = v_i (\cos 15^\circ) t$$

$$= (20 \frac{\text{m}}{\text{s}})(0.966)(1.58 \text{ s})$$

$$= 30.5 \text{ m}$$

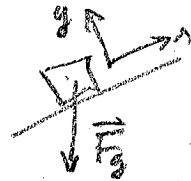
10. A wooden block of mass 2.0 kg is given initial velocity of 5.0 m/s at the base of a ramp that is inclined at an angle 25° as shown. The coefficient of kinetic friction of the block on the ramp is 0.3. Find the maximum distance d the block travels up the ramp.

Defining x -axis up along ramp
and y -axis perpendicular to ramp;



$$m a_y = F_y = F_N - F_{gy}$$

$$0 = F_N - mg \cos 25^\circ$$



$$\therefore F_N = mg \cos 25^\circ$$

$$m a_x = F_x = -\mu_k F_N - mg \sin 25^\circ$$

$$= -\mu_k mg \cos 25^\circ - mg \sin 25^\circ$$

$$\therefore a_x = -(\mu_k \cos 25^\circ + \sin 25^\circ)g$$

$$= -(0.3(0.906) + 0.423)(9.8 \text{ m/s}^2)$$

$$= -6.81 \text{ m/s}^2$$

$$v_f^2 - v_i^2 = 2a_x \Delta x$$

0 at maximum distance up ramp

$$\therefore \Delta x = -\frac{v_i^2}{2a_x} = -\frac{(5.0 \text{ m/s})^2}{2(-6.81 \text{ m/s}^2)} = 1.84 \text{ m}$$