

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

1 A B C D E

2 A B C D E

3 A B C D E

4 A B C D E

5 A B C D E

6 A B C D E

7 A B C D E

8 A B C D E

1. Only one of the following statements is correct. The correct statement is:
 - a. Average velocity is not a vector quantity.
 - b. The average velocity can always be expressed as one-half the sum of the initial and final velocities.
 - c. An accelerating body always changes its direction of motion.
 - d. The instantaneous velocity is equal to the rate of change of the displacement with time.
 - e. A body undergoing constant acceleration changes its velocity by larger increments in succeeding equal time intervals.

2. A stone with a mass m is dropped from an airplane that has a horizontal velocity v at a height h above a lake. If air resistance is neglected, the horizontal distance D from the point on the lake directly below the point of release to the point where the stone strikes the water is given by which formula?

a. $D = v(2h/g)^2$	b. $D = v^2/(2g)$
c. $D = 2mv/\sqrt{2gh}$	d. $D = v\sqrt{2h/g}$

e. None of these is correct.

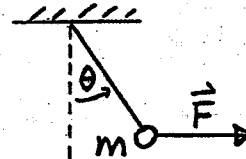
3. An airplane is heading due east. The airspeed indicator shows that the plane is moving with a speed of 370 km/h relative to the air. If the wind is blowing from the south at 92.5 km/h, the velocity of the airplane relative to the ground is:

a. 357 km/h at 14° east of north.	b. 381 km/h at 104° east of north.
c. 381 km/h at 76° east of north.	d. 357 km/h at 76° east of north.

e. 381 km/h at 14° east of north.

4. A baseball is thrown in the air with an initial speed $v_0 = 24$ m/s in a direction 30° above the horizontal. Ignore air resistance. When the ball is at the highest point in its flight,
- its velocity and acceleration are both zero.
 - its velocity is zero but its acceleration is nonzero.
 - its velocity is nonzero but its acceleration is zero.
 - its velocity and acceleration are both nonzero.
 - Insufficient information is given to answer correctly.

5. A pendulum bob of mass m is held at an angle θ from the vertical by a horizontal force \vec{F} as shown. Letting g be the acceleration due to gravity, the magnitude of \vec{F} is:



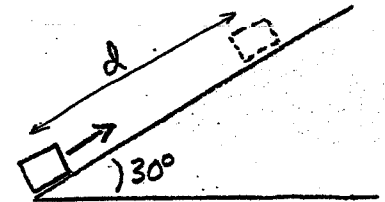
- $mg \sin \theta$
 - $mg \cos \theta$
 - $\frac{mg}{\sin \theta \cos \theta}$
 - $mg \tan \theta$
 - $mg \sin \theta \cos \theta$
6. Two groups of five men are engaged in a tug-of-war, each man pulling with a force of 900 N. If the rope does not move, the tension in it is (in N)
- 0
 - 900
 - 1800
 - 4500
 - 9000



7. 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)
- 8
 - 6
 - 2
 - 14
 - 2
8. A car is moving horizontally at a constant speed of 10 m/s around a curve which is in the shape of a circle with radius 50 m. A pendulum hangs freely inside the car. What is the angle of the pendulum with respect to the vertical?
- 1°
 - 11°
 - 44°
 - 63°
 - 79°

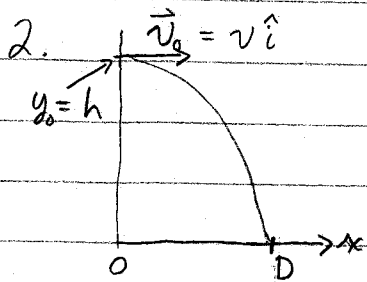
PART B: ANSWER QUESTIONS 9 AND 10 IN THE SPACE PROVIDED, SHOWING ALL YOUR WORK

9. A wooden block of mass 1.5 kg is given initial velocity of 5 m/s at the base of a ramp that is inclined at an angle 30° as shown. The coefficient of kinetic friction of the block on the ramp is 0.4. Find the maximum distance d the block travels up the ramp.



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10. Referring to the situation described in Question 9: After reaching the maximum distance of travel up the ramp, determine whether the block remains at rest at that point or slides back down. Let the coefficient of static friction of the block on the ramp be 0.6.

1. (d)



$$v_x = v$$

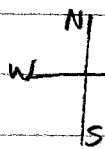
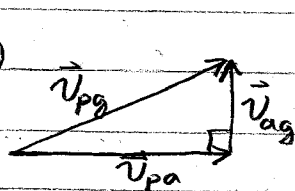
$$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$$

$$0 = h - \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

$$D = v_x t = v \sqrt{\frac{2h}{g}} \quad (d)$$

3. (c)

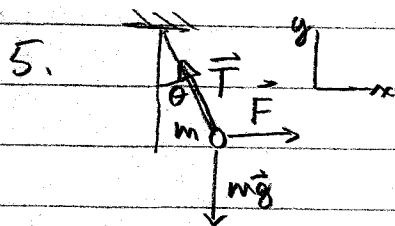


p = plane a = air g = ground

$$\theta = \tan^{-1} \frac{v_{ag}}{v_{pa}} = \tan^{-1} \frac{92.5}{370} = \tan^{-1} 0.25 \approx 14^\circ \text{ north of east}$$

$$v_{pg} = (v_{pa}^2 + v_{ag}^2)^{1/2} = (370^2 + 92.5^2)^{1/2} = 381 \text{ km/h} \quad \text{or } 90 - 14 = 76^\circ \text{ east of north}$$

4. (d)



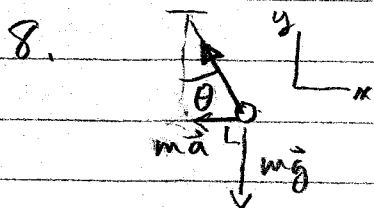
$$0 = m\vec{a} = \vec{T} + \vec{F} + m\vec{g} \Rightarrow \vec{F} + m\vec{g} = -\vec{T} \text{ has components}$$

$$x: F = -T_x = T \sin \theta \quad y: -mg = -T \cos \theta$$

$$\therefore \frac{F}{mg} = \frac{T \sin \theta}{T \cos \theta} \Rightarrow F = mg \tan \theta \quad (d)$$

$$6. \quad \overleftarrow{F_{man}} \quad \overrightarrow{T} \quad \overleftarrow{T} \quad \overrightarrow{F_{man}} \quad T = F_{man} = 5 \times 900 \text{ N} = 4500 \text{ N} \quad (d)$$

$$7. \quad W = \vec{F} \cdot \vec{d} = (4\hat{i} - 2\hat{j}) \cdot (2\hat{i} + 3\hat{j}) = 8 - 6 = 2 \text{ J} \quad (c)$$



$$m\vec{a} = \vec{T} + m\vec{g}$$

$$x: m v^2 / r = T \sin \theta \quad y: 0 = T \cos \theta - mg$$

$$\text{so } mg = T \cos \theta$$

$$\therefore \frac{m v^2}{r} = \frac{T \sin \theta}{T \cos \theta} \Rightarrow \frac{v^2}{r g} = \tan \theta$$

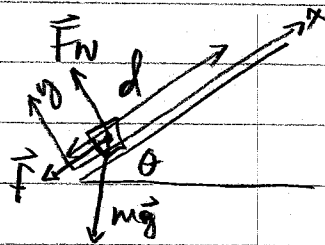
$$\tan \theta = \frac{(10 \text{ m/s})^2}{(50 \text{ m})(10 \text{ m/s}^2)} = \frac{1}{5} \Rightarrow \theta = \tan^{-1} \frac{1}{5} \approx 11^\circ \quad (b)$$

9. Use $\vec{F} = m\vec{a}$ to find acceleration of block:

$$m a_y = F_y = F_N - mg \cos \theta \Rightarrow F_N = mg \cos \theta$$

$$m a_x = F_x = F_f + m g_x = -\mu_k F_N - mg \sin \theta$$

$$= -\mu_k mg \cos \theta - mg \sin \theta$$



$$\therefore a_x = -g (\mu_k \cos \theta + \sin \theta)$$

$$= -(10 \text{ m/s}^2) \left(0.4 \frac{\cos 30^\circ}{\sqrt{3}/2} + \frac{\sin 30^\circ}{1/2} \right) = -8.46 \text{ m/s}^2$$

(8.29 m/s², $g = 9.8 \text{ m/s}^2$)

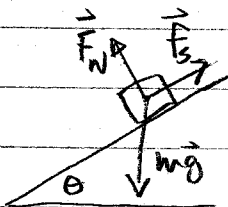
$$v_x^2 = v_{0x}^2 + 2 a_x (x - x_0)$$

\therefore Maximum distance block travels up ramp is

$$d = x - x_0 = \frac{1}{2 a_x} (v_x^2 - v_{0x}^2) = \frac{1}{2(-8.46 \text{ m/s}^2)} (0 - (5 \text{ m/s})^2) = 1.48 \text{ m}$$

(1.51)

10.



Calculate \vec{F}_s needed to hold block at rest, and see whether it is less than $F_{s, \text{max}} = \mu_s F_N$, or not,

As above, $0 = m a_y = F_N - mg \cos \theta \Rightarrow F_N = mg \cos \theta$

At rest, $0 = m a_x = F_s - mg \sin \theta \Rightarrow F_s = mg \sin \theta$ required.

But $F_s \leq F_{s, \text{max}} = \mu_s F_N = \mu_s mg \cos \theta$

\therefore require $mg \sin \theta \leq \mu_s mg \cos \theta$

i.e. $\tan \theta \leq \mu_s$

Since $\tan 30^\circ = 0.577$ is less than $\mu_s = 0.6$, \therefore block stays at rest at its maximum distance of travel up the ramp.