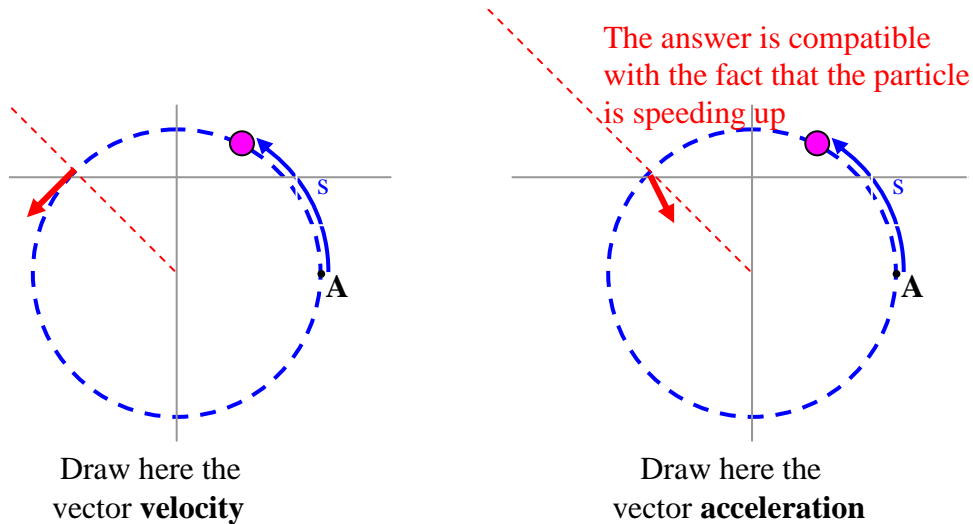


1. A particle moves along a circular path in the counter-clockwise direction, as indicated in the graph below. At $t = 0$, the particle starts its motion at the point "A". For $t > 0$, the distance traveled along the circular path is given by $s(t) = (\pi/8 \text{ m/s})t + (\pi/8 \text{ m/s}^2) t^2$.
- 1A Draw schematically, but as accurate as possible, both the vector velocity and the vector acceleration that the particle has at $t = 2 \text{ s}$.

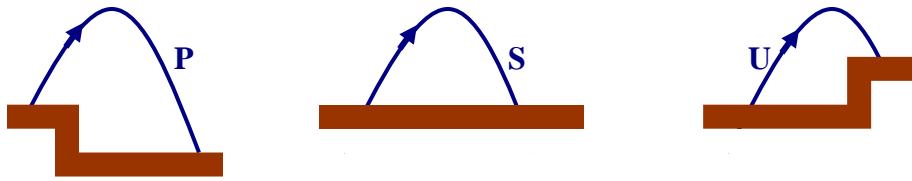


- 1B Express analytically the vector velocity that the particle has at $t = 2 \text{ s}$. Give your answer in terms of the unit vector \vec{i} and \vec{j} .

ANSWER: $-(5\pi/8 \text{ m/s})(\cos \pi/4) \vec{i} - (5\pi/8 \text{ m/s})(\cos \pi/4) \vec{j}$
 $= -1.4 \vec{i} - 1.4 \vec{j}$

Note: For 1A: If you drew the vectors velocity and acceleration at the particle's position indicated in the figure, the grader will consider it correct (provided those vectors are drawn correctly.) **For 1B:** Your answer should be compatible with your answer in 1A.

2. 2A. The figure shows three situations in which identical projectiles are launched (at the same level) at identical initial speeds and angles. The projectiles do not land on the same terrain, however. Rank the situations according to the final speeds of the projectiles just before they land, greatest first.

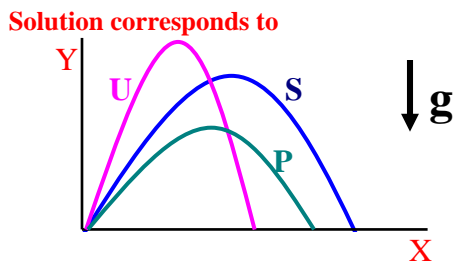
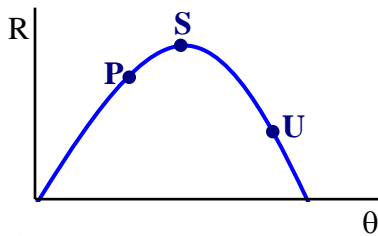


ANSWER: **P, S, U**

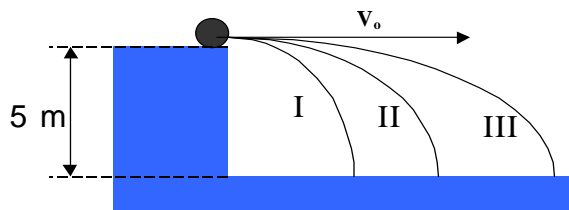
2B. A ball is shot from ground level over level ground at a certain initial speed. The figure below gives the range of the ball versus its launch angle. Rank, from greatest to lowest, the three lettered points on the plot according to:

i) The total flight time of the ball ANSWER: **U, S, P**

ii) The ball's speed at maximum height ANSWER: **P, S, U**

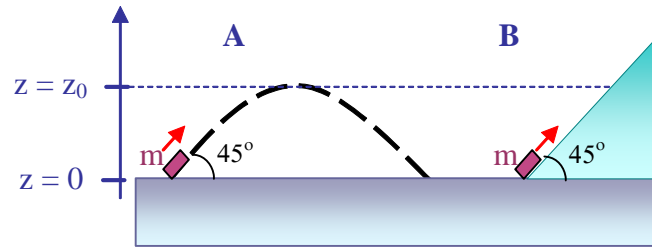


3. 3.A Three balls are thrown simultaneously from the same height, although with different speed. (The initial velocity of each ball points in the X direction, and there exist no other force except the gravity acting on the balls). The path followed by each ball is indicated in the figure. Which of the balls hit the floor first



- a) I b) II c) all tie d) III e) NA

3.B At $t=0$ two small objects A and B of the same mass “m” are thrown simultaneously from the level $z=0$ and with the same initial speed (the initial velocity makes 45° with the horizontal) . One of the objects travels free in the air (its trajectory is indicated in the graph) while the other travels along a frictionless surface of a 45° ramp. Which of the following expressions is correct?

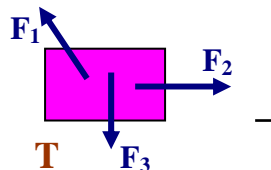
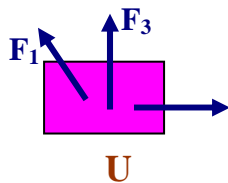
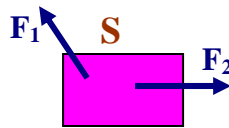
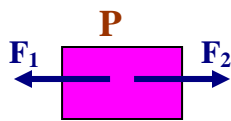


- a) When block A reaches its maximum height, its velocity is zero.
 b) The maximum height that the block B reaches is lower than $Z=Z_0$.
 c) When they return to the floor level $z=0$, both have the same speed.
 d) Both blocks reach the same max height.
 e) None of the above choices are correct.

4. 4.A The figure shows overhead views of four situations in which forces act on a block that lies on a frictionless floor. If the force magnitudes are chosen properly, in which situations is it possible that the block is

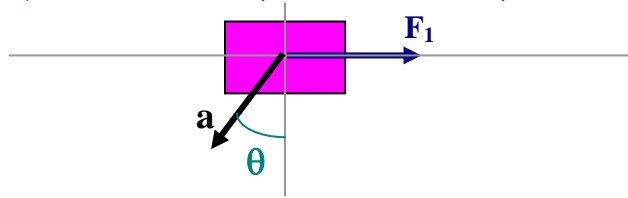
i) stationary ANSWER P, T

ii) moving with a constant velocity ANSWER P, T



4.B There are two forces acting on the 2 kg box shown in the figure below, but only one is shown. For $F_1 = 20 \text{ N}$, $a = 12 \text{ m/s}^2$, and $\theta = 30^\circ$, calculate the magnitude of the second force (in units of Newton.)

- a) 38.2 N b) 16.8 N c) 8.3 N d) 4.7 N e) NA



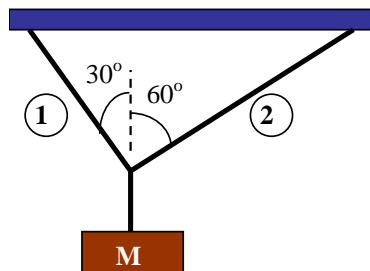
5. 5A A typical sugar cube has an edge length of 1 cm. If you had a cubical box that contained a mole of sugar cubes, what would be its edge length? (One mole = 6.02×10^{23} units)

- a) 216 m b) 206 Km c) $2 \times 10^6 \text{ m}$ d) 844 Km e) NA

5B The Antarctica is roughly semicircular, with a radius of 2000 Km. The average thickness of its ice-cover is 3000 m. How many cubic centimeters of ice does Antarctica contains (Ignore the curvature of Earth.)

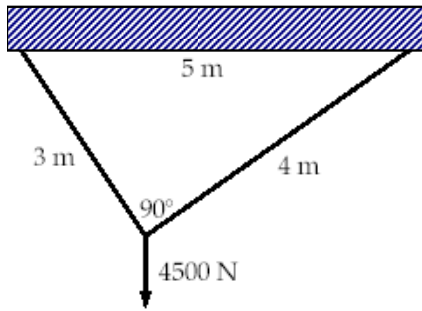
- a) 4.7×10^{21} b) 2.1×10^{16} c) 1.9×10^{22} d) 7.4×10^{27} e) NA

6. 6.A If $M = 6 \text{ kg}$, what is the tension in string 1 (in units of Newton)?



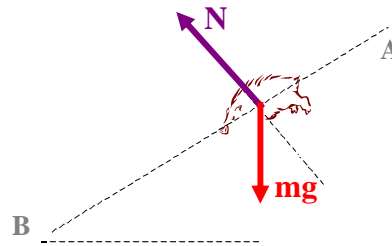
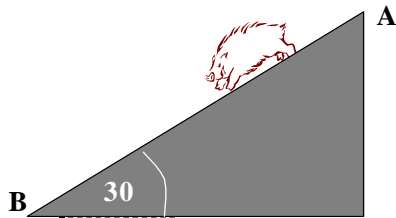
- a) 39 b) 51 c) 29 d) 44 e) NA

6.B A cable system hanging from a beam is configured as shown in the diagram below. The lengths of the cables are also indicated. A 4500 N weight hangs from the cables. What is the tension in the 4 m cable in Newtons?



- a) 2500, b) 3600 c) 4200 **d) 2700** e) NA

7. A slide-loving pig slides down a frictionless 30 degrees slide (see left-side figure).
8A On the right-side figure, draw all the forces acting only on the pig.



- 7B** Find the magnitude of the acceleration (in m/s^2) of the pig on its way down.
a) 4.9 b) 9.8 c) 8.5 **d) 4.2** e) NA

8. **8A** In the figure shown, the horizontal force \mathbf{F}_1 of magnitude 10N is applied to a box on a floor, but the box does not slide. Then, as the magnitude of the vertical force \mathbf{F}_2 is increased from zero, do the following quantities increase, decrease or stay the same:

i) The magnitude of the frictional force f on the box

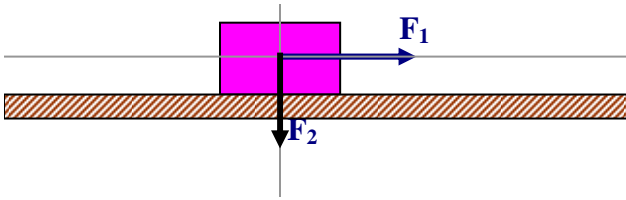
ANSWER SAME

ii) The magnitude of the NORMAL force N on the box from the floor

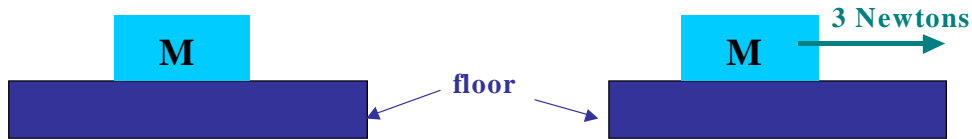
ANSWER INCREASES

iii) The maximum value $f_{s,\text{max}}$ of the magnitude of the static frictional force on the box

ANSWER INCREASES



8B A blok of mass $M = 2 \text{ Kg}$ is at rest (see figure at the left). Indicate what will happen if an external force of 3 Newtons is applied to that mass. ($\mu_s = 0.2$, and $\mu_k = 0.15$).



- a) The blok of mass M will remain at rest
- b) The blok of mass M will move to the right
- c) The normal force acting on M will decrease
- d) The weight of the blok will increase
- e) NA

=====

BONUS QUESTION

(5 points)

Two trains having a speed of 30 Km/h, are headed at each other on the same straight track. A bird that can fly 60 km/h flies off the front of one train when they are 90 Km apart and heads directly for the other train. On reaching the other train, the bird flies directly back to the first train and so forth. What is the total distance the bird travels before the trains collide?

ANSWER 90 Km

Helpful formulas

Average velocity = $\Delta \mathbf{x} / \Delta t$

instantaneous velocity $\mathbf{v} = d \mathbf{x} / dt$

Average acceleration = $\Delta \mathbf{v} / \Delta t$

instantaneous acceleration $\mathbf{a} = d \mathbf{v} / dt$

Motion under constant acceleration “a”

$$v = v_0 + a t$$

$$x - x_0 = v_0 t + (1/2) a t^2$$

$$v^2 = v_0^2 + 2 a (x - x_0)$$

Free fall

$$v_y = v_{0y} - g t$$

$$g = 9.8 \text{ m/s}^2$$

$$y - y_0 = v_{0y} t - (1/2) g t^2$$

$$x - x_0 = v_{0x} t$$

$$g = 32 \text{ ft/s}^2$$

$$v_y^2 = v_{0y}^2 - 2 g (y - y_0)$$

Projectile motion

$$x = x_0 + (v_0 \cos \theta) t$$

$$y = y_0 + (v_0 \sin \theta) t - (1/2) g t^2$$

$$\text{Range } R = (v_0^2/g) \sin 2\theta$$

Uniform circular motion

$$a = v^2/R$$

Newton's second law

$$F = ma$$
