**PHYSICS 100A**
**First Exam (75 minutes, Chapters 1 – 6)**
**Fall 2007**

**NAME: ________________________________** **SCORE: ___________**

*Note: All quantities without explicit units are in SI units.*

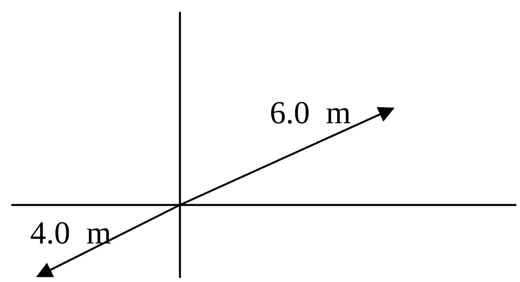
PART I - MULTIPLE CHOICE. EACH QUESTION IS WORTH 5 POINTS FOR A TOTAL OF 40 POINTS.

1. An airplane starts from rest and accelerates at 10.8 m/s$^2$. What is its speed at the end of a 400 m long runway?
   a) 37.0 m/s
   b) 4320 m/s
   c) 65.7 m/s
   d) 93.0 m/s

$$v^2 = v_0^2 + 2a\Delta x$$
$$= 0 + 2(10.8)(400)$$
$$v = \sqrt{2(10.8)(400)} = 92.95$$

2. Ball A is thrown horizontally and ball B is thrown upward.
   a) They have the same downward acceleration
   b) Ball A has the greater downward acceleration
   c) Neither has any downward acceleration
   d) Ball B has the greater downward acceleration

3. Vector $\vec{A}$ has magnitude 6.0 m and points 30$^0$ north of east. Vector $\vec{B}$ has magnitude 4.0 m and points 30$^0$ south of west. The resultant vector $\vec{A}+\vec{B}$ is given by
   a) 2.0 m at an angle 30$^0$ north of east.
   b) 10.0 m at an angle 60$^0$ east of north.
   c) 2.0 m at an angle 60$^0$ north of east.
   d) 10.0 m at an angle 30$^0$ north of east.

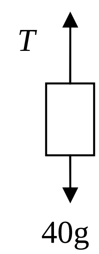



4. Vectors $\vec{A}$ and $\vec{B}$ satisfy the equation $\vec{A}+\vec{B}=0$. These vectors satisfy one of the following statements.
   a) Vectors $\vec{A}$ and $\vec{B}$ point in the same direction.
   b) Vectors $\vec{A}$ and $\vec{B}$ are at right angles to each other.
   c) The magnitude of $\vec{A}$ is the negative of the magnitude of $\vec{B}$.
   d) Vectors $\vec{A}$ and $\vec{B}$ have the same magnitude.

5. An athlete throws a ball with a velocity of 40 m/s at an angle of $20^0$ above the horizontal. Which of the following statements is true in this case?
   a) The vertical component of the velocity changes sign after the ball attains it maximum height.
   b) The vertical component of the velocity remains constant.
   c) The horizontal component of the velocity changes sign after the ball attains its maximum height.
   d) The horizontal component of the velocity changes with time.

6. A 40.0 kg crate is being lowered by means of a rope. Its downward acceleration is 2.00 $m/s^2$. What is the force exerted by the rope on the crate?
   a) 47.2 N
   b) 312 N
   c) 40.0 N
   d) 323 N

$$mg - T = ma \quad \Rightarrow$$
$$T = m(g-a)$$
$$= 40.0(9.81 - 2.00)$$
$$= 312$$

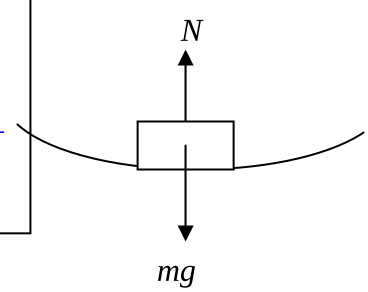



7. When a mass of 25.0 grams is suspended from a spring and lowered slowly until the spring stops stretching, the spring stretches 2.00 cm. What is the spring constant of the spring?
   a) 7.85 N/m
   b) 12.3 N/m
   c) 1.25 N/m
   d) 0.800 N/m

$$kx = mg \quad \Rightarrow$$
$$k(0.02\text{ m}) = (0.025\text{ kg})(9.81\text{ m/s}^2)$$
$$k = (0.025\text{ kg})(9.81\text{ m/s}^2)/(0.02\text{ m})$$
$$= 12.26\text{ N/m}$$

8. A car moving at 10.0 m/s encounters a depression in the road that has a circular cross-section with a radius of 30.0 m. What is the normal force exerted by the seat of the car on a 60.0 kg passenger when the car is at the bottom of the depression?
   a) 389 N
   b) 200 N
   c) 589 N
   d) 789 N

$$N - mg = \frac{mv^2}{r} \quad \Rightarrow$$
$$N - (60.0\text{ kg})(9.81\text{ m/s}^2) = \frac{(60.0\text{ kg})(10\text{ m/s})^2}{(30.0\text{ m})}$$
$$N = 788.6N$$



PART II - PROBLEM SOLVING. EACH PROBLEM IS WORTH 20 POINTS FOR A TOTAL OF 60 POINTS.

1) In a relay race, runner A is carrying the baton and has a constant speed of 3.4 m/s. When A is 25.0 m behind the second runner B, B starts from rest and accelerates at 0.14 m/s$^2$. Take the starting position of runner B as the origin of the coordinate system.

a) What are the initial speed and initial position of runner B? (4 pts)
   Initial speed of B is 0.0 m/s since B starts from rest.
   Initial position of B is 0.0 m since B is at the origin.

b) What are the initial speed and initial position of runner A? (4 pts)
   Initial speed of A is 3.4 m/s since A runs at constant speed.
   Initial position of A is -25.0 m since A is behind B at the moment B starts running.

c) How long will it take for A to catch up with B to pass the baton to B? Hint: A and B are at the same position when this happens. (8 pts)
   Let the position where A catches up to B be denoted by $x$.
   From the motion of A:

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \quad \Rightarrow \quad x = -25 + 3.4t$$

   From the motion of B:

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \quad \Rightarrow \quad x = 0 + 0 + \frac{1}{2}\left(0.14 \text{ m/s}^2\right)t^2$$

   Since the two positions are equal,

$$-25 + 3.4t = \frac{1}{2}\left(0.14 \text{ m/s}^2\right)t^2 \quad \Rightarrow \quad 0.07t^2 - 3.4t + 25 = 0$$

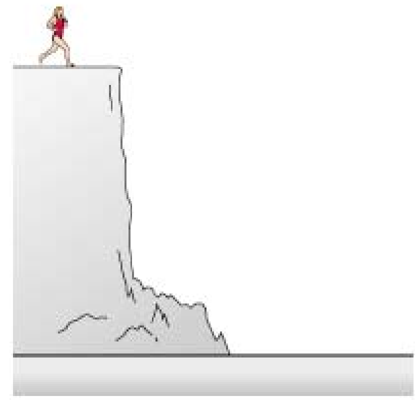
$$t = \frac{3.4 \pm \sqrt{3.4^2 - 4(0.07)(25)}}{2(0.07)} = 39.54 \text{ s or } 9.03 \text{ s}$$

   We take the smaller time as the time when A catches up to B. The latter time signifies the fact that A moves past B at 9.03 s but B, because of her acceleration, will eventually increase her speed to a large enough value to catch up with, and pass A.

d) How fast is B moving when A overtakes her? (4 pts)
   At the time of 9.03 s, the speed of B is given by:

$$v = v_0 + at \quad \Rightarrow \quad v = 0 + \left(0.14 \text{ m/s}^2\right)(9.03 \text{ s}) = 1.26 \text{ m/s}$$

2) A daring swimmer jumps off a cliff with a running horizontal leap into the ocean. The ledge at the bottom of the cliff is 1.50 m wide and 9.50 m below the top of the cliff (see diagram).



a) Choose the origin to be at the top of the cliff. What are the horizontal and vertical displacements of the edge of the ledge? (4 pts)
Horizontal displacement of edge of ledge is 1.50 m

Vertical displacement of edge of ledge is -9.50 m

b) What must her minimum speed be just as she leaves the top of the cliff so that she will miss the ledge at the bottom, (10 pts)
Let $t$ be the time it takes for her to reach the bottom. From the vertical motion:

$$y = v_{0y}t - \frac{1}{2}gt^2 \quad \Rightarrow \quad (-9.50\text{ m}) = 0 - \frac{1}{2}(9.81\text{ m/s}^2)t^2$$

Solving, we obtain:

$$t = \sqrt{\frac{2(9.5)}{9.81}} = 1.39\text{ s}$$

At this time, her horizontal distance must be at least equal to 1.50 m. Hence the minimum speed is

$$v_x = \frac{x}{t} = \frac{1.5\text{ m}}{1.39\text{ s}} = 1.08\text{ m/s}$$

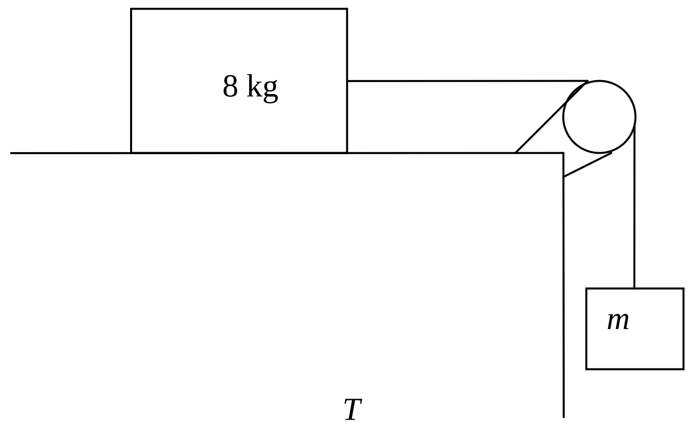
c) How fast is the diver moving just before she hits the water? (6 pts)
The horizontal component of her velocity just before hitting the water is 1.08 m/s as this does not change. The vertical component of her velocity is:

$$v_y = v_{0y} - gt = 0 - (9.81\text{ m/s}^2)(1.39\text{ s}) = -13.6\text{ m/s}$$

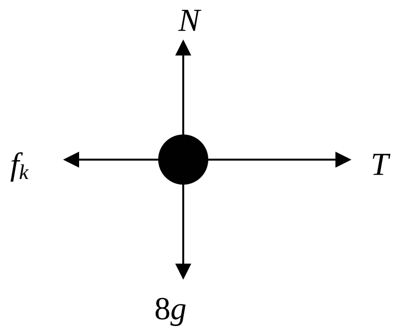
Hence, the speed with which she hits the water is:

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{1.08^2 + 13.6^2} = 13.7\text{ m/s}$$

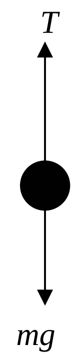
3) Two blocks are connected by a string as shown in the figure below. The 8.0 kg block rests on a rough horizontal surface with coefficient of kinetic friction equal to 0.40. The block that is hanging has an unknown mass *m*. When released, the two blocks accelerate with an acceleration of 1.2 m/s$^2$.




a) Draw a free body diagram for the 8.0 kg block. (5 pts)




b) Draw a free body diagram for the unknown block *m*. (5 pts)




c) From the above, set up the equations and solve for the unknown mass *m*. (10 pts)

From the first free body diagram,

$$\sum F_x = ma_x \quad \Rightarrow \quad T - f_k = 8(1.2)$$

$$\sum F_y = ma_y \quad \Rightarrow \quad N - 8g = 0$$

From the second equation,

$$N = 8g \quad \text{and from} \quad f_k = \mu_k N, \quad \Rightarrow \quad f_k = 0.40(8g) = 31.4 \text{ N}$$

From the second free body diagram,

$$\sum F_y = ma_y \quad \Rightarrow \quad mg - T = ma$$

Substituting in for *T* from the first equation and for the value of $f_k$:

$$mg - (8(1.2) + 31.4) = m(1.2)$$

Solving for *m*, we obtain:

$$m = 4.76 \text{ kg}$$