Matter and Motion – Wed. Oct. 4, 2017
Physics Quiz #1

Name: KEY

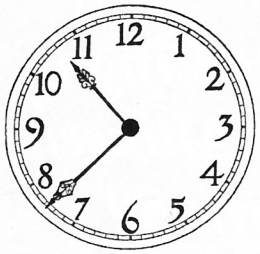
- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- Show/explain all work/reasoning. You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 9:00 and ends promptly at 9:15

1) Rolling downhill, a cyclist hits a top speed of 42 miles per hour. How many meters per second is this?

$$42\ \frac{mi}{h}\ \frac{1h}{3600s}\ \frac{1.6km}{1mi}\ \frac{1000m}{1km} = 18.7\ m/s \rightarrow 19\ m/s$$

2) A hand of an analog clock (shown below) moves from the 12:00 straight-up position to the 2:00 position. Through what angle (in radians) does it pass? (You may express your answer either in decimal form or as a fraction.)

$$\frac{2\pi}{6} = \frac{1}{6}(2\pi) = \frac{\pi}{3}$$

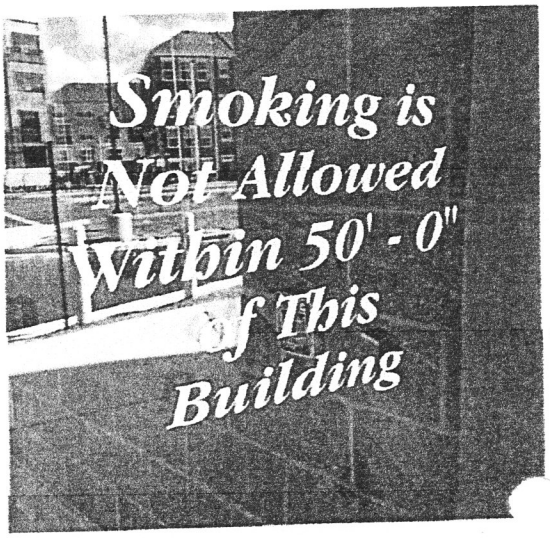


3) One cubic foot is how many milliliters (*1 milliliter = 1 cm³*)?

$$(1\,ft)^3 \left(\frac{12\,in}{1\,ft}\right)^3 \left(\frac{2.54\,cm}{1\,in}\right)^3 = 2.8 \times 10^4\ cm^3$$

4) The picture shows a warning, "Smoking is Not Allowed Within 50′ – 0″ of This Building." How many meters from the building should a smoker be before smoking?

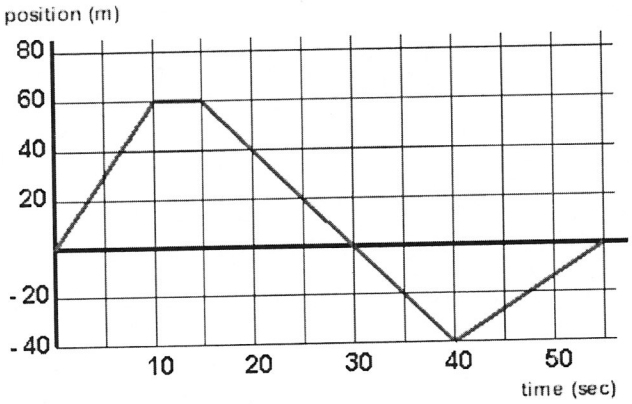
$$50\,ft \ \frac{12\,in}{1\,ft} \ \frac{2.54\,cm}{1\,in} \ \frac{1\,m}{100\,cm} = \boxed{15\,m}$$



Matter and Motion – Tue. Oct. 10, 2017
Physics Quiz #2

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- Show/explain all work/reasoning. You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 1:00 and ends promptly at 1:30



1) The graph above represents position vs. time for an object in one-dimensional motion. The following questions refer to the motion described by this graph
   a) [2 points] When is the object moving at the greatest speed (between what two times)?

   0 - 10s

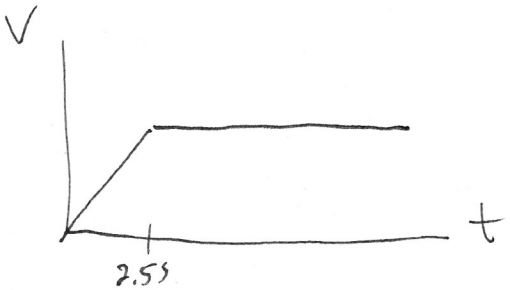
   b) [2 points] What is the object's greatest speed (in m/s)?

   6 m/s

   c) [2 points] What is the object's slowest speed (in m/s)?

   0 m/s

2) A sprinter runs a 100 meter race. Starting from rest, their acceleration is 4.5 m/s^2 for the first 2.5 seconds of the race, after which they run at a constant velocity the rest of the race.
   a) [2 points] Sketch a graph of velocity vs. time



b) [4 points] What will be the sprinter's final speed?

$$\left(4.5\frac{m}{s^2}\right)\cdot(2.5\,s) = 11.25\ m/s$$

c) [4 points] What distance will the sprinter cover in the first 2.5 seconds?

$$\frac{1}{2}\left(4.5\frac{m}{s^2}\right)(2.5\,s)^2 = 14.06\ m$$

d) [4 points] What will be the sprinter's total time to complete the race?

$$\frac{(100\,m - 14.06\,m)}{11.25\ m/s} = 7.64\,s + 2.5\,s = 10.14\,s$$

Matter and Motion – Wed. Oct. 18, 2017
Physics Quiz #3

Name: KEY

This quiz is for you to display your personal understanding of program material

- You may use a single 3 inch by 5 inch note card and a calculator
- Show/explain all work/reasoning. You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 9:00 and ends promptly at 9:30

1) [6 points] The LCM-3000 benchtop centrifuge spins at 3000 revolutions per minute, creating an acceleration 1700 times gravity (g=9.8 m/s²) at the bottom of the centrifuge tubes. What is the radius of the circle traced by the tubes as they spin?

$v = \frac{3000 \cdot 2\pi r}{60\,s}$ $\quad a = \frac{v^2}{r} \rightarrow r = \frac{v^2}{a} = \left(\frac{3000 \cdot 2\pi}{60\,s}\right)^2 r^2$ $\quad v = r\omega \rightarrow v^2 = r^2\omega^2$

$a = \frac{v^2}{r} = \frac{r^2\omega^2}{r} = r\omega^2$

$r =$

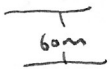
$\Rightarrow r = \frac{a}{\omega^2} = \frac{9.8\,m/s^2 \cdot 1700}{}$

$\omega = 3000\,\frac{rev}{min} \cdot \frac{1\,min}{60\,s} \cdot \frac{2\pi\,rad}{1\,rev}$

$= 100\pi\,\frac{rad}{s}$

$r = \frac{1700 \cdot 9.8\,m/s^2}{(100\pi\,rad/s)^2} = 0.17\,m = \boxed{17\,cm}$

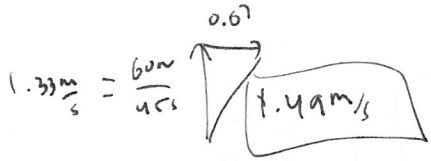
2) [6 points total] Alice rows across a 60 m wide river that flows from east to west, aiming her boat directly north. It takes her 45 seconds to cross the river, and she lands 30 meters downstream of her original location. Let the +x direction be east and the +y direction be north.



a) [2 points] What is the velocity of the current in the river?

$\frac{30\,m}{45\,s} = \boxed{0.67\,\frac{m}{s}\ east}$

b) [4 points] As seen from the shore, what was her velocity? Express this velocity as a magnitude and a direction.



$\theta = \tan^{-1} 0.5 = \boxed{26.6°}$

3) [2 points] Which of the following correctly expresses the relationship among the vectors in the figure?

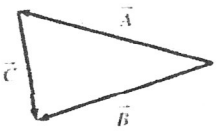
a) $\vec{A} + \vec{B} = \vec{C}$

b) $\vec{B} = \vec{A} + \vec{C}$

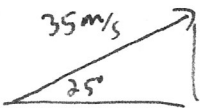
c) $\vec{A} = \vec{B} + \vec{C}$

d) $\vec{C} = \vec{A} + \vec{B}$

e) None of the above?



4) [6 points] A thrown rock has an initial velocity of 35 m/s directed at an angle 25 degrees above horizontal. What is its velocity 2.0 seconds later? Neglect air drag and note that the rock experiences a constant acceleration of 9.8 m/s² downward. (You may express this either in components or as a magnitude and direction.)

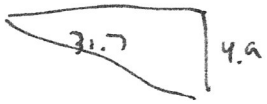


$V_y = 35 \text{ m/s} \cdot \sin 25° = 14.7 \text{ m/s}$

$V_x = 35 \text{ m/s} \cos 25° = 31.7 \text{ m/s}$

$V_y = 14.7 \text{ m/s} - \left(9.8 \frac{\text{m}}{\text{s}^2}\right)(2.0 \text{ s})$

$\vec{V} = 31.7 \frac{\text{m}}{\text{s}} \hat{i} + -4.9 \frac{\text{m}}{\text{s}} \hat{j}$



$\theta = \tan^{-1} \frac{4.9}{31.7} = 8.8°$

$\vec{V} = 32 \text{ m/s}$ 8.8° below horizontal

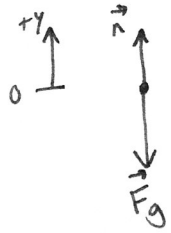
Matter and Motion – Tue. Oct. 24, 2017
Physics Quiz #4

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- *Show/explain all work/reasoning.* You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 1:00 and ends promptly at 1:30

1) [10 points total] A 66 kg passenger rides stands on a scale in an elevator. The scale indicates that the normal force exerted on the passenger is 620 N.

a) [6 points] What is the magnitude of the acceleration of the elevator?



$F_{net} = ma_y$

$n - F_g = ma_y$

$n = 620N$

$F_g = mg$

$m = 66kg$

$$a_y = \frac{n - F_g}{m} = \frac{620N - (66kg)(9.8\frac{m}{s^2})}{66kg} = -0.406\frac{m}{s^2}$$

$a_y = -0.41\frac{m}{s^2}$

magnitude is $0.41\frac{m}{s^2}$

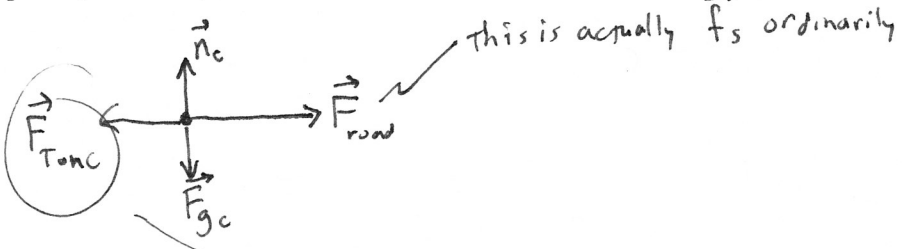
b) [2 points] What is the direction of this acceleration? downward

c) [2 points] What can you say about the *velocity* of the elevator? Is the speed constant, increasing, decreasing? What combinations of direction and speed change are consistent with this situation? (Answer briefly but completely; two sentences should be plenty.)

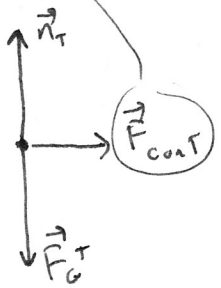
Velocity is unknown. The elevator could be going down and speeding up, or it could be going up but slowing down

2) [10 points total] A car of mass m= 1200 kg pushes a truck of mass M=2400 kg. Assume the truck rolls with negligible resistance. The car accelerates at a steady rate of 0.60 m/s² along the level road.

a) [2 points] Draw a FBD of the car. Include all forces (not just the forces acting in the horizontal direction).



b) [2 points] Draw a FBD of the truck. Include all forces (not just the forces acting in the horizontal direction).



c) [2 points] Consider your two FBDs. Are any forces in those diagrams Newton's Third Law force pairs? Clearly indicate which forces constitute such pairs.

$\vec{F}_{T on C}$ in part(a) and $\vec{F}_{C on T}$ in part(b) are a 3NL force pair

d) [4 points] What is the force exerted by the car on the truck? Indicate clearly the magnitude and direction of this force.

$F_{net\,x} = Ma_x$

From FBD on part 2, only force on truck w/ x component is $\vec{F}_{C on T}$ Plug & chug...

$$F_{C on T} = M_{tot}\, a = (2400\text{kg})\left(0.60 \tfrac{m}{s^2}\right)$$

$$= 1440\text{N}$$

$\boxed{F = 1400\text{N}}$ to 2 sig figs

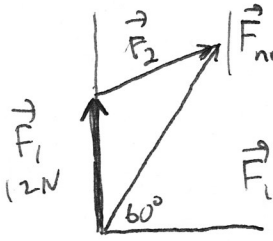
Matter and Motion – Wed. Nov 1, 2017
Physics Quiz #5

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- *Show/explain all work/reasoning*. You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 9:00 and ends promptly at 9:30

1) [8 points total] A 12 kg box accelerates at a rate of 2.0 m/s² in a direction 60° counterclockwise from the x axis. Two forces act on this box. One has a magnitude of 12 N and points in the +y direction. What is the other force? (You may specify the force either by its components F_x and F_y or as a magnitude F and direction θ measured counterclockwise from the x axis.)

Resolve F_{net} into x & y components

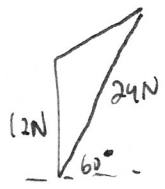


$|\vec{F}_{net}| = (12kg)(2.0\frac{m}{s^2}) = 24N$

$\vec{F}_1 + \vec{F}_2 = \vec{F}_{net}$

$(F_{net})_x = 24N \cos 60° = 12N$

$(F_{net})_y = 24N \sin 60° = 20.8N$



$F_{1x} + F_{2x} = (F_{net})_x$

$0 + F_{2x} = 12N$

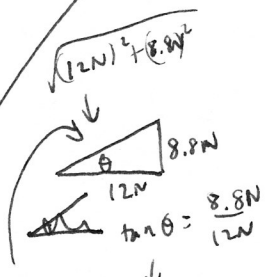
$F_{2x} = 12N$

$F_{1y} + F_{2y} = (F_{net})_y$

$12N + F_{2y} = 20.8N$

$F_{2y} = 8.8N$

$\vec{F}_2 = 12N\,\hat{i} + 8.8N\,\hat{j}$



or

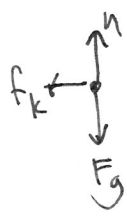
$\vec{F} = 14.9N$ at 36° CCW from x axis

2) [4 points total] A force $\vec{F} = -1.0\ N\,\hat{\imath} + 3.0\ N\,\hat{\jmath}$ acts on an object as it moves in a straight line from the origin to the location (-3.0 m, -4.0 m). What is the work done by this force?

$W = \vec{F} \cdot \Delta\vec{r} = (-1.0N\,\hat{i} + 3.0N\,\hat{j}) \cdot (-3.0m\,\hat{i} + (-4.0m)\,\hat{j})$

$= (-1N)(-3m) + (3N)(-4m) = \boxed{-9J}$

3) [8 points] A box slides on a floor with an initial speed of 6.0 m/s. If it comes to rest after 3.0 seconds, what is the coefficient of kinetic friction μ_k?



N2L (y): $0 = ma_y = n - mg$ $\quad n = mg$

$f_k = \mu_k n = \mu_k mg$

N2L (x): $ma = -f_k = \mu_k mg$

$a = -\mu_k g \rightarrow \mu_k = \frac{-a}{g}$

kinematics: $v = v_0 + at$ $\quad v = 0$, $v_0 = 6\ m/s$, $t = 3s$

$0 = v_0 + at$

$a = -\frac{v_0}{t} = -\frac{6\ m/s}{3s} = -2\ m/s^2$

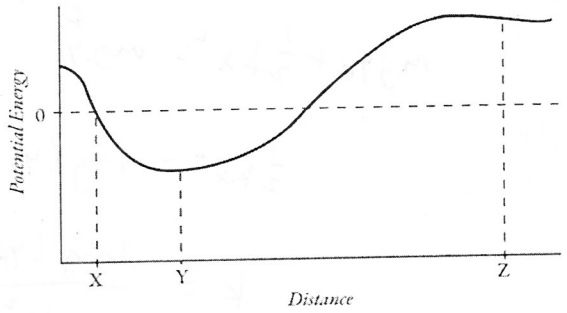
$\therefore \mu_k = -\frac{a}{g} = -\frac{(-2\ m/s^2)}{9.8\ m/s^2} = \boxed{0.20}$

Matter and Motion – Wed. Nov 7, 2017
Physics Quiz #6a

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- *Show/explain all work/reasoning.* You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 8:00 and ends promptly at 8:30

1. [2 points] The plot in the figure shows the potential energy of a particle, due to the force exerted on it by another particle, as a function of distance. At which of the three points labeled in the figure is the speed of the particle greatest?



a. X
b. Y
c. Z
d. Not enough information to tell

2. [8 points] A car on a roller coaster starts at zero speed at an elevation above the ground of 28 m. It coasts down a slope, and then climbs a hill. At the top of the hill its speed is 6.0 m/s. What is the elevation of the hill? Neglect any frictional effects.

Before $\quad$ After

$U_g \quad K$

$mgy_0 + 0 = mgy_f + K = \frac{1}{2}mv_f^2$

$mgy_0 = mgy_f + \frac{1}{2}mv_f^2$

$2g(y_0 - y_f) = v_f^2$

$y_0 - y_f = \frac{v_f^2}{2g} = 1.8\,m$

$y_f = y_0 - 1.8\,m = 26.2\,m$

3. [10 points] A 220 g ball is placed atop an uncompressed spring and is pushed down a distance of 12 cm. When the ball is released, it launches straight up and reaches a maximum height of 2.5 m above the spring's initial height. What is the spring constant k?

$y_0 = -.12\,m$ $\quad v_0 = 0$ $\quad U_{sp_0} = \frac{1}{2}kx^2$

$y_f = 2.5\,m$ $\quad v_f = 0$ $\quad U_{sp_f} = 0$

$U_{sp_0} + K_0^{\nearrow 0} + U_{g_0} = U_{g_f}^{\nearrow 0} + K_f^{\nearrow 0} + U_{g_f}$

$mgy_0 + \frac{1}{2}kx^2 = mgy_f$

$\frac{1}{2}kx^2 = mg(y_f - y_0)$

$k = \frac{2mg(y_f - y_0)}{x^2}$

$= \frac{2(.220\,kg)(2.5\,m - (-0.12\,m))(9.8\,m/s^2)}{(0.12\,m)^2}$

$k = 780\,\frac{N}{m}$

Matter and Motion – Wed. Nov 7, 2017
Physics Quiz #6b

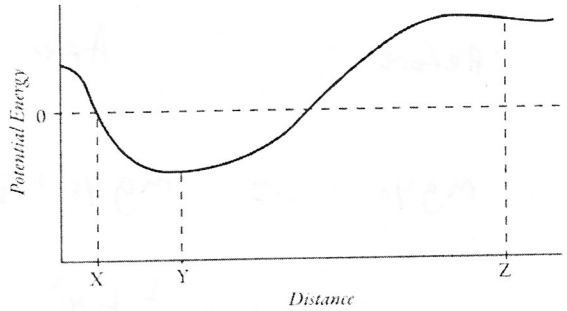
Name: KEY

This quiz is for you to display your personal understanding of program material

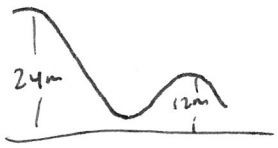
- You may use a single 3 inch by 5 inch note card and a calculator
- *Show/explain all work/reasoning.* You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 1:00 and ends promptly at 1:30

1. [2 points] The plot in the figure shows the potential energy of a particle, due to the force exerted on it by another particle, as a function of distance. At which of the three points labeled in the figure is the magnitude of the force on the particle greatest?

   a. X
   b. Y
   c. Z
   d. Not enough information to tell



2. [8 points] A car on a roller coaster starts at zero speed at an elevation above the ground of 24 m. It coasts down a slope, and then climbs a hill. The top of the hill is at an elevation of 12 m. What is the speed of the car at the top of the hill? Neglect any frictional effects.



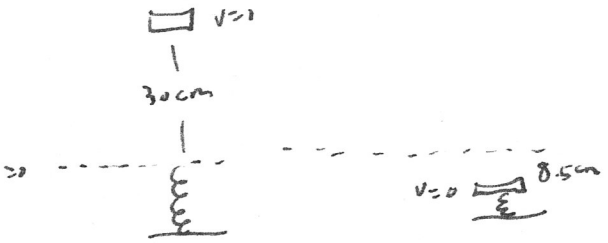
$$mgy_0 = mgy + \frac{1}{2}mv^2$$

$$2g(y_0 - y) = v^2$$

$$v = \sqrt{2g(y_0 - y)}$$

$$= \sqrt{2(9.8\,m/s^2)(12\,m)} = \boxed{15\,m/s}$$

3. *[10 points] A* 0.45 *kg book falls on a spring from a height* 30 cm *above the top of the initially uncompressed spring. The spring compresses a maximum distance of 8.5 cm after the initial fall. What is the spring constant k?*



Before After

$$mgy_0 = mgy_f + \frac{1}{2}kx^2 \qquad x = -y_f$$

$$mg(y_0 - y_f) = \frac{1}{2}ky_f^2$$

$$k = \frac{2mg(y_0 - y_f)}{y_f^2} = \frac{2(0.45\,kg)(9.8\,\frac{m}{s^2})(0.3\,m - (-0.085\,m))}{(0.085\,m)^2}$$

$$\boxed{k = 470\,\frac{N}{m}}$$

Matter and Motion – Wed. Nov 15, 2017
Physics Quiz #7

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- ***Show/explain all work/reasoning.*** You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 9:00 and ends promptly at 9:30

1. [10 points total] Two carts on a track collide and bounce off one another. Cart A (m_A=250 g) moved with an initial velocity of +1.2 m/s in the +x direction while Cart B (m_B=500 g) was initially at rest. After the collision, the velocity of Cart A is -0.3 m/s.
   a. [6 points] What is the final velocity of Cart B?

$\vec{p}_i = \vec{p}_f$

$m_A V_0 + m_B(0) = m_A V_A + m_B V_B$

$V_0 = +1.2 \frac{m}{s}$ $\quad m_A = 0.25 kg$

$V_A = -0.3 \frac{m}{s}$ $\quad m_B = 0.5 kg$

$V_B = \frac{m_A}{m_B}(V_0 + V_A)$

$= \frac{0.25 kg}{0.5 kg}\left(1.2 \frac{m}{s} - (-0.3 \frac{m}{s})\right) = \boxed{0.75 \frac{m}{s}}$

   b. [4 points] Was kinetic energy conserved in this collision? Support your answer by calculating the kinetic energies before and after the collision.

No

Before $\frac{1}{2}(0.25 kg)(1.2 m/s)^2 = 0.18 J$

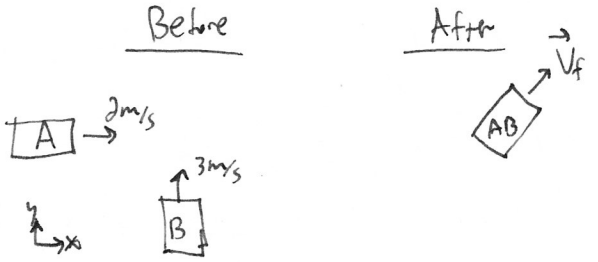
After $\frac{1}{2}(0.25 kg)(0.3 m/s)^2 = 0.01125 J$

$\frac{1}{2}(0.5 kg)(0.75 \frac{m}{s})^2 = 0.1406 J$

sum $0.152 J$

less than initial K

2. [10 points] Car A (mass m_A=1200 kg) traveling east at 2.0 m/s with collides with car B (mass m_B=1800 kg) traveling north at 3.0 m/s. After the collision they slide together. What is the velocity of the two cars after the collision? (Remember that velocity is a *vector* as you write your final answer!)



$$\vec{p}_i = \vec{p}_f$$

$$\vec{p}_A + \vec{p}_B = \vec{p}_f$$

$$m_A\vec{v}_A + m_B\vec{v}_B = (m_A+m_B)\vec{v}_f$$

Break into components ① $m_A v_A = (m_A+m_B)v_{fx}$

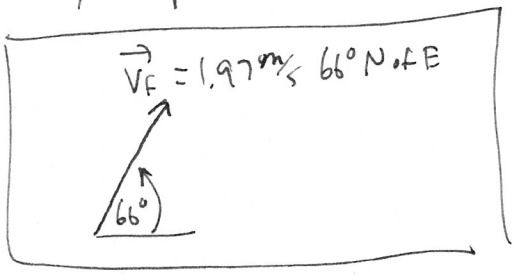
② $m_B v_B = (m_A+m_B)v_{fy}$

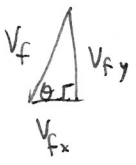
① $v_{fx} = \frac{m_A}{m_A+m_B} v_A = \left(\frac{1200\text{ kg}}{(1200\text{ kg}+1800\text{ kg})}\right)(2\text{ m/s}) = 0.8\text{ m/s}$

② $v_{fy} = \frac{m_B}{(m_A+m_B)} v_B = \left(\frac{1800\text{ kg}}{(1200\text{ kg}+1800\text{ kg})}\right)(3\text{ m/s}) = 1.8\text{ m/s}$

$$\vec{v}_f = 0.8\,\frac{\text{m}}{\text{s}}\,\hat{i} + 1.8\,\frac{\text{m}}{\text{s}}\,\hat{j}$$

Or if you prefer speed & direction...





$$\tan\theta = \frac{V_{fy}}{V_{fx}}$$

$$\theta = \tan^{-1}\frac{V_{fy}}{V_{fx}}$$

$$= \tan^{-1}\frac{1.8\text{ m/s}}{0.8\text{ m/s}}$$

$$\theta = 66°$$

$$V_f = \sqrt{V_{fx}^2 + V_{fy}^2}$$

$$= \sqrt{(0.8\text{ m/s})^2 + (1.8\text{ m/s})^2}$$

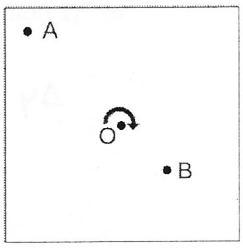
$$V_f = 1.97\text{ m/s}$$

Matter and Motion – Wed. Nov 29, 2017
Physics Quiz #8

Name: KEY

- This quiz is for you to display your personal understanding of program material
- You may use a single 3 inch by 5 inch note card and a calculator
- ***Show/explain all work/reasoning.*** You will be evaluated on clarity/completeness of process, not simply on answer
- The quiz begins at 9:00 and ends promptly at 9:30

1. [4 points] A square object rotates about its center with a constant angular speed ω in the direction about point O shown by the curved arrow (see diagram at right).



   a. [2 points] Using the convention given by the text, is the rotation shown ***positive*** (+) or ***negative*** (-)? (circle one)
   b. [2 points] Consider points A and B on the square. Point A is twice as far from O as Point B. Which of the following statements are true? (Select all that are true; there may be more than one!)
      i. The linear acceleration of B is twice as great as the linear acceleration of A.
      ii. The angular velocity of A is twice as great as the angular velocity of B.
      iii. A is moving twice as fast as B.
      iv. The linear acceleration of A is twice as great as the linear acceleration of B.
      v. A and B have the same linear acceleration.

2. [6 points] A triangular plate *OAB* is in a horizontal plane. Three forces, with magnitudes $F_1 = 6.0$ N, $F_2 = 9.0$ N, and $F_3 = 7.0$ N, act on the plate, which is pivoted about a vertical axis through point *O*. In the figure, $\vec{F}_2$ is perpendicular to *OB*. Find the sum of the torques about the vertical (i.e. out of the page) axis through point *O*, acting on the plate, due to forces F_1, F_2, and F_3

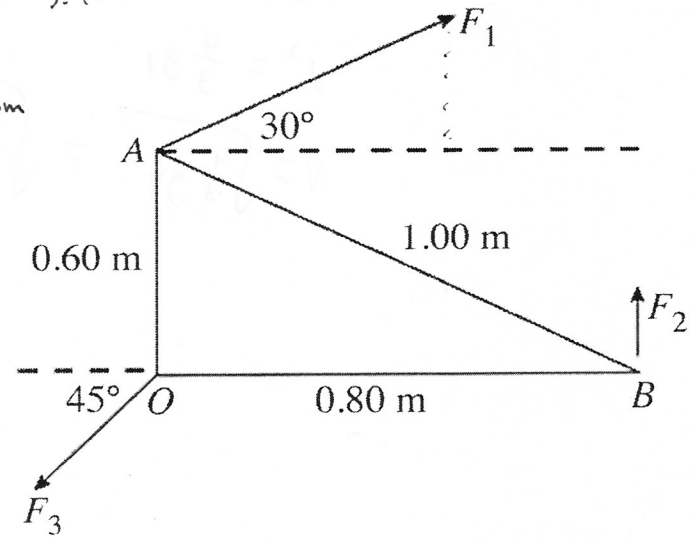
$\tau_3 = 0$

$\tau_1 = -r_1 F_\perp = -(0.6\text{m})(6\text{N}\cos 30°) = -3.12\text{ N·m}$

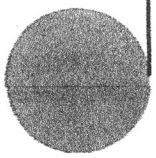
$\tau_2 = r_2 F_\perp = (0.8\text{m})(9\text{N}) = 7.2\text{ N·m}$

$\Sigma\tau = -3.12\text{N·m} + 7.20\text{N·m} + 0$

$= 4.08\text{ N·m}$



3. [10 points] A lightweight string is wrapped tightly around a spool. You hold the string and release the spool from rest, holding the string steady. As the spool falls, the string unwinds from the spool as shown to the right. The spool has a diameter of 4.0 cm and a mass of 45 grams and is a uniform solid cylinder (not hollow). After the spool has fallen a distance of 1.0 m...



a. [2 points] How many full revolutions has the spool completed?

$\Delta y = r\theta \quad \theta = \frac{\Delta y}{r} = \frac{1.0\,m}{.02\,m} = 50\,rad$

$50\,rad \frac{1\,rev}{2\pi\,rad} = 7.96\,rev$

b. [8 points] What is the velocity of the spool?

Use C.E

$mgy = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \qquad v = r\omega \text{ so } \frac{1}{2}I\omega^2 = \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v}{r}\right)^2$

$I = \frac{1}{2}mr^2 \qquad = \frac{1}{4}mv^2$

$= \frac{1}{2}mv^2 + \frac{1}{4}mv^2$

$= \frac{3}{4}mv^2$

$4mgy = 3mv^2$

$v^2 = \frac{4}{3}gy$

$v = \sqrt{\frac{4}{3}gy} = \sqrt{\frac{4}{3}\left(9.8\frac{m}{s^2}\right)(1.0\,m)} = 3.6\frac{m}{s}$