Physics 1120: Math Review Solutions

1. Convert the following:
   (a) 3.5 km^2 to m^2

$$3.5\,km^2 = 3.5\,km\,km = 3.5\,km \times \frac{1000\,m}{1\,km} \times km \times \frac{1000\,m}{1\,km} = 3.5\times10^6\,m^2$$

   (b) 56 g/cm^3 to kg/m^3

$$56\frac{g}{cm^3} = 56\frac{g}{cm\times cm\times cm}$$
$$= 56\frac{g}{cm\times cm\times cm}\times\frac{1\,kg}{1000\,g}\times\frac{100\,cm}{1\,m}\times\frac{100\,cm}{1\,m}\times\frac{100\,cm}{1\,m}$$
$$= 5.6\times10^4\,\frac{kg}{m^3}$$

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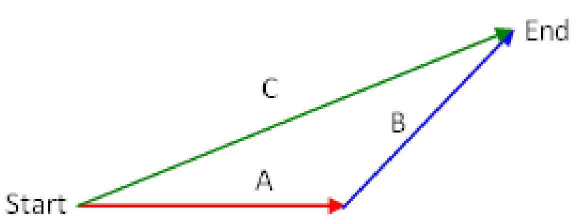
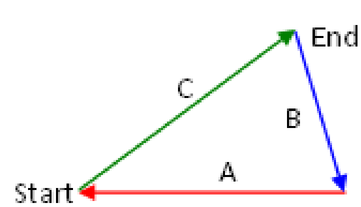
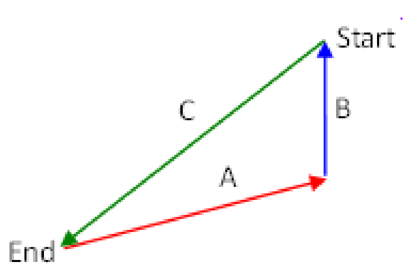
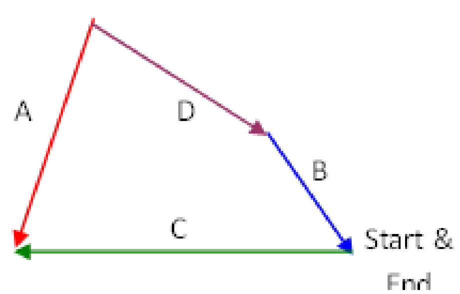
2. Write vectors equations for each diagram below.

(a)


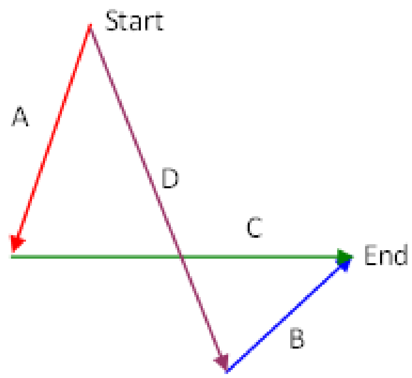
(b)


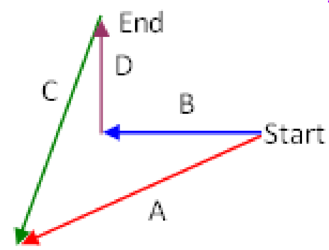
(c)


(d)


(e)

(f)





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

(c) $\vec{C} = -\vec{B} + -\vec{A}$ (d) $\vec{C} - \vec{A} + \vec{D} + \vec{B} = 0$

(e) $\vec{A} + \vec{C} = \vec{D} + \vec{B}$ (f) $\vec{A} - \vec{C} = \vec{B} + \vec{D}$

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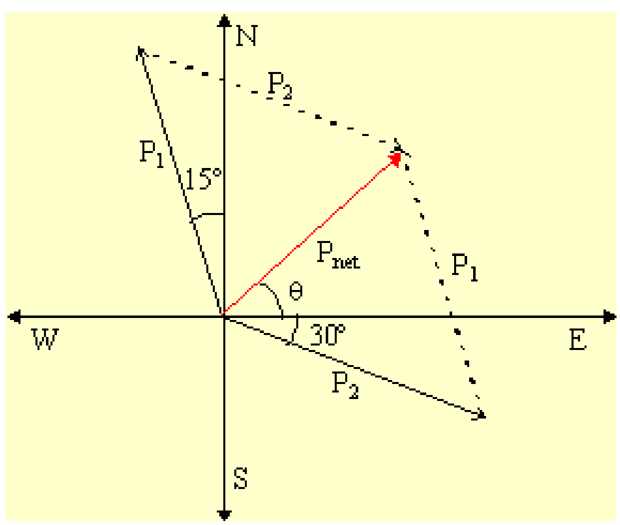
3. Momentum is a vector quantity given by **p** = mv. A system consists of 2 particles: one of mass 150 g moving at 125 cm/s at 15.0° west of north, and the other of mass 200 g moving at 90 cm/s at 30.0° south of east. What is the net momentum of the system?

First we get the magnitude of the momenta: $P_1 = 0.150\,kg \times 1.25\,m/s = 0.1875\,kg \cdot m/s$ and $P_2 = 0.200\,kg \times 0.90\,m/s = 0.1800\,kg \cdot m/s$. Next we neatly sketch the problem and its solution.



Vector problems are solved by breaking the given vectors into their ***i*** and ***j*** components.

$$\hat{\mathbf{i}} \qquad\qquad \hat{\mathbf{j}}$$

$$P_{1x} = -0.1875\,kg\cdot m/s \times \sin(15.0°) \qquad P_{1y} = +0.1875\,kg\cdot m/s \times \cos(15.0°)$$
$$= -0.04853\,kg\cdot m/s \qquad = +0.18111\,kg\cdot m/s$$

$$P_{2x} = +0.1800\,kg\cdot m/s \times \cos(30.0°) \qquad P_{2y} = -0.1800\,kg\cdot m/s \times \sin(30.0°)$$
$$= +0.15588\,kg\cdot m/s \qquad = -0.09000\,kg\cdot m/s$$

$$P_{net\,x} = P_{1x} + P_{2x} = +0.10735\,kg\cdot m/s \quad P_{net\,y} = P_{1y} + P_{2y} = +0.09111\,kg\cdot m/s$$

Using Pythagoras' Theorem, $P_{net} = \sqrt{P_{net\,x}^2 + P_{net\,y}^2} = 0.141\,kg\cdot m/s$. We use trigonometry to find the direction. The angle is $\theta = \tan^{-1}\left(\frac{P_{net\,y}}{P_{net\,x}}\right) = 40.3°$. The total or net momentum is thus 0.141 kg m/s at 40.3° north of east.

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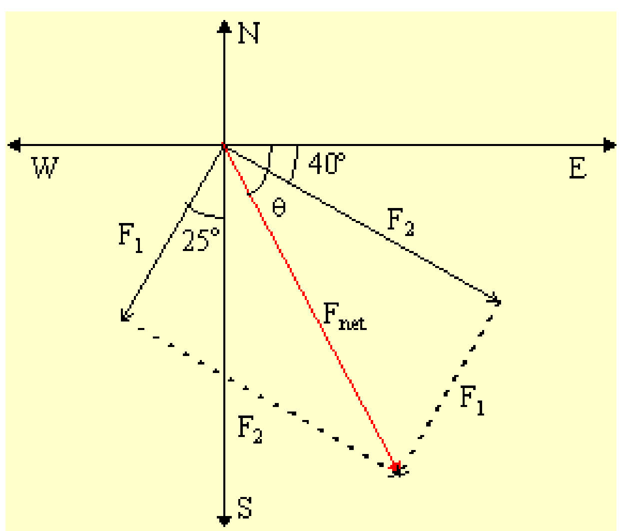
4. Two forces act on a body. The first is $\mathbf{F_1}$ = 135 N at 25.0° west of south, and the second is $\mathbf{F_2}$ = 190 N acting at 40.0° south of east. Find the net force acting on the body.

First we neatly sketch the problem and its solution.



Vector problems are solved by breaking the given vectors into their ***i*** and ***j*** components.

$$\hat{\mathbf{i}} \qquad\qquad\qquad\qquad \hat{\mathbf{j}}$$

$F_{1x} = -135N \times \sin(25.0°) = -57.05N$ $\quad$ $F_{1y} = -135N \times \cos(25.0°) = -122.35N$

$F_{2x} = +190N \times \cos(40.0°) = +145.55N$ $\quad$ $F_{2y} = -190N \times \sin(40.0°) = -122.13N$

$F_{net\,x} = F_{1x} + F_{2x} = 88.50\,N$ $\quad$ $F_{net\,y} = F_{1y} + F_{2y} = -244.48N$

Using Pythagoras' Theorem, $F_{net} = \sqrt{F_{net\,x}^2 + F_{net\,y}^2} = 260N$. We use trigonometry to find the direction.

The angle is $\theta = \tan^{-1}\left(\dfrac{F_{net\,y}}{F_{net\,x}}\right) = 70.1°$. The total or net force is thus 260 N at 70.1° south of east. It would be more common to state this as 260 N at 19.9° east of south.

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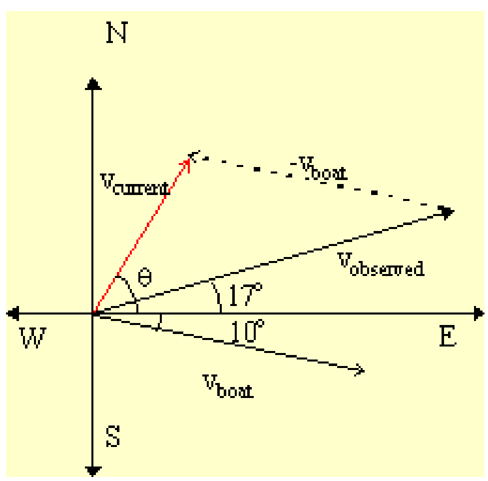
5. A person on the shore at English Bay observes that the net velocity of a person in a boat is 2.75 m/s at 17.0° north of east. The boat is moving relative to the water at 1.90 m/s heading 10.0° south of east. Determine the velocity of the water current relative to the person on shore.

First, we must realize that the velocity that the observer sees is the sum of the velocity of the boat and the velocity of the current, i.e. $\vec{v}_{observed} = \vec{v}_{boat} + \vec{v}_{current}$. Since we are looking for $\vec{v}_{current}$, we are dealing with the subtraction of vectors which is the addition of the negative of a vector, i.e. $\vec{v}_{current} = \vec{v}_{observed} - \vec{v}_{boat} = \vec{v}_{observed} + (-\vec{v}_{boat})$. To solve this, or any other vector problem, we sketch the solution first.



Vector problems are solved by breaking the given vectors into their ***i*** and ***j*** components.

$\hat{\mathbf{i}}$ | $\hat{\mathbf{j}}$

$$v_{observed\,x} = 2.75\,m/s \times \cos(17.0°) = 2.630\,m/s \qquad v_{observed\,y} = 2.75\,m/s \times \sin(17.0°) = 0.804\,m/s$$

$$v_{boat\,x} = 1.90\,m/s \times \cos(10.0°) = 1.871\,m/s \qquad v_{boat\,y} = -1.90\,m/s \times \sin(10.0°) = -0.330\,m/s$$

$$v_{current\,x} = v_{observed\,x} - v_{boat\,x} = 0.759\,m/s \qquad v_{current\,y} = v_{observed\,y} - v_{boat\,y} = 1.134\,m/s$$

Using Pythagoras' Theorem, $v_{current} = \sqrt{v_{current\,x}^2 + v_{current\,y}^2} = 1.36\,m/s$. We use trigonometry to find the direction. The angle is $\theta = \tan^{-1}\left(\frac{v_{current\,y}}{v_{current\,x}}\right) = 56.2°$. The velocity of the current is thus 1.36 m/s at 56.2° north of east.

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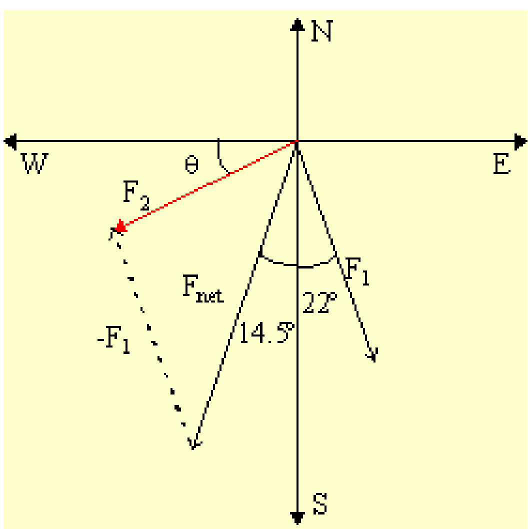
6. The net force of two forces acting on a body is 3500 N at 14.5° west of south. One force is 2100 N at 22.0° east of south. What is the other force?

Since we are told the total force and one of the forces, the other force is given by $F_2 = F_{net} - F_1 = F_{net} + (-F_1)$. To solve this, or any other vector problem, we sketch the solution first.



Vector problems are solved by breaking the given vectors into their ***i*** and ***j*** components.

$$\hat{\mathbf{i}} \qquad\qquad \hat{\mathbf{j}}$$

$$F_{net\,x} = -3500\,N\sin(14.5°) = -876.33\,N \qquad F_{net\,y} = -3500\,N\cos(14.5°) = -3388.52\,N$$

$$F_{1x} = +2100\,N\sin(22.0°) = +786.67\,N \qquad F_{1y} = -2100\,N\cos(22.0°) = -1947.07\,N$$

$$F_{2x} = F_{net\,x} - F_{1x} = -1663.00\,N \qquad F_{2y} = F_{net\,y} - F_{1y} = -1441.43\,N$$

Using Pythagoras' Theorem, $F_2 = \sqrt{F_{2x}^2 + F_{2y}^2} = 2200\,N$. We use trigonometry to find the direction. The angle is $\theta = \tan^{-1}\left(\frac{F_{2y}}{F_{2x}}\right) = 40.9°$. The second force is thus 2200 N at 40.9° south of west.

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