Physics 2414, Spring 2005
Group Exercise 3, Feb 17, 2005

Name 1: ____________ OUID 1: ____________

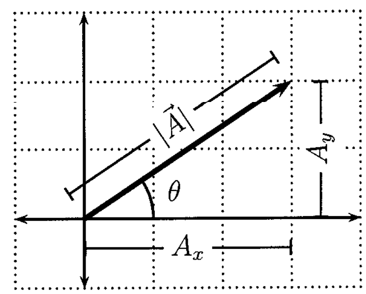
Name 2: ____________ OUID 2: ____________

Name 3: Solutions OUID 3: Solutions

Name 4: ____________ OUID 4: ____________

Section Number: ____

Vectors



Terminology:

(a) x-component of a vector $\vec{A}$ is A_x.

(b) y-component of a vector $\vec{A}$ is A_y.

(c) Magnitude of a vector $\vec{A}$ is $|\vec{A}|$. This is a positive quantity by definition.

(d) Direction of a vector $\vec{A}$ is θ.

Mathematical description of a vector:

$$\vec{A} = A_x + A_y \tag{1}$$

Necessary relationships:

$$A_x = |\vec{A}|\cos\theta_A \qquad |\vec{A}| = \sqrt{A_x^2 + A_y^2} \tag{2}$$

$$A_y = |\vec{A}|\sin\theta_A \qquad \theta_A = \tan^{-1}\left(\frac{A_y}{A_x}\right) \tag{3}$$

Problems

1. *Elise, Bob, and the Movie theater:*
Elise's house is represented by the point 'E' in figure 1. She visits Bob at his house represented by point 'B' in figure 1. Bob's house is

720 meters from Elise's house if you walk 34 degrees in the direction North of East. Elise and Bob together go to the Movie theater 'M' which is 1080 meters from Bob's house if you walk 68 degrees in the direction West of North.

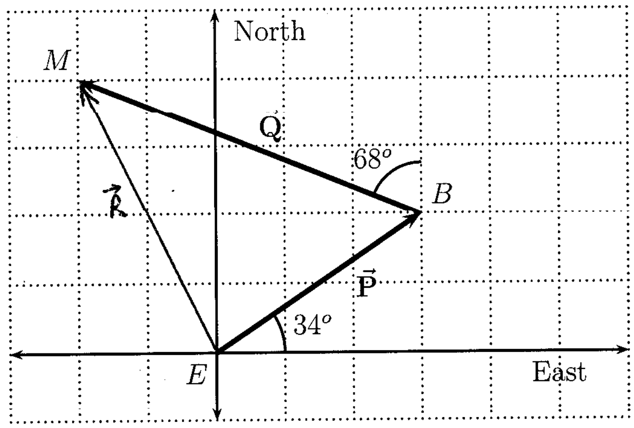


Figure 1

(a) Vector $\vec{\mathbf{P}}$ represents the displacement vector connecting the points 'E' and 'B'. Find the x-component and y-component of the vector $\vec{\mathbf{P}}$.

$P_x = 720 \cos 34 = 597\text{ m}$

$P_y = 720 \sin 34 = 403\text{ m}$

$\vec{P} = (597\text{ m})_x + (403\text{ m})_y$

(b) Vector $\vec{\mathbf{Q}}$ represents the displacement vector connecting the points 'B' and 'M'. Find the x-component and y-component of the vector $\vec{\mathbf{Q}}$.

$Q_x = -1080 \sin 68 = -1001\text{ m}$

$Q_y = +1080 \cos 68 = +405\text{ m}$

$\vec{Q} = (-1001\text{ m})_x + (405\text{ m})_y$

(c) Let us denote the total displacement of Elise from point 'E' to point 'M' by the vector $\vec{\mathbf{R}}$. Find the x-component and y-component of the vector $\vec{\mathbf{R}}$. (Hint: $\vec{\mathbf{R}} = \vec{\mathbf{P}} + \vec{\mathbf{Q}}$.)

$R_x = P_x + Q_x = -1001\text{ m} + 597\text{ m} = -404\text{ m}$

$R_y = P_y + Q_y = +403\text{ m} + 405\text{ m} = +808\text{ m}$

$\vec{R} = (-404\text{ m})_x + (808\text{ m})_y$

(d) Draw the vector $\vec{\mathbf{R}}$ pictorially in figure 1.

(e) How far is the movie theater from Elise's house if one walks along a straight direction?

$$|\vec{R}| = \sqrt{R_x^2 + R_y^2} = \sqrt{404^2 + 808^2} = 903 \text{ m}$$

(f) What is the angle with direction East one should walk from Elise's house to reach the Movie theater?

$$\theta_R = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{808}{-404}\right) = -63^\circ$$

Options: 63° South of East
(OR)
(180-63) North of East

Diagram in (d) implies (180-63).

2. *Spiderman!*

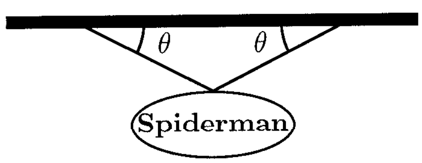


Figure 2

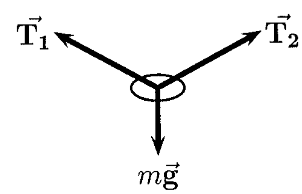


Figure 3

Elise and Bob decide to watch the movie Spiderman. In a particular shot Spiderman is hanging on to the skyscrapers using two *massless* ropes as shown in figure 2.

(a) The free body diagram for the Spiderman is shown in figure 3. Write down the x-component and y-component of the force equation (Newton's law) for the Spiderman in the particular shot.

$\vec{F}_{net} = m\vec{a}$

$\vec{T}_1 + \vec{T}_2 + m\vec{g} = 0 \quad (\because \vec{a} = 0)$

x-comp : $-T_1 \cos\theta + T_2 \cos\theta = 0$

y-comp : $T_1 \sin\theta + T_2 \sin\theta - mg = 0$

(b) Using the y-component of the force equation, show that the magnitude of the tensions in the two ropes is the same.

x- comp $\quad -T_1 \cos\theta + T_2 \cos\theta = 0$

$$T_1 \cos\theta = T_2 \cos\theta$$

$$T_1 = T_2$$

(c) Using the y-component of the force equation, calculate the tension in the rope if mass of the signboard is $m = 75$ kg and $\theta = 27^o$.

$$T_1 \sin\theta + T_2 \sin\theta - mg = 0$$

$$2 T_1 \sin\theta = mg \quad (\text{using (b)})$$

$$T_1 = \frac{mg}{2 \sin\theta}$$

$$= \frac{75 \text{ kg} \times 9.8 \text{ m/s}^2}{2 \times \sin(27)}$$

$$= 817 \text{ N}$$