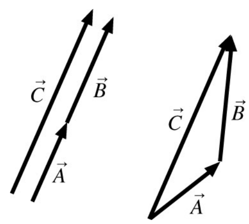
Physics 4A
Chapter 3 HW Solutions

Chapter 3
Conceptual Questions: 2, 3, 9
Exercises & Problems: 6, 11, 13, 17, 22, 23, 25, 38, 43

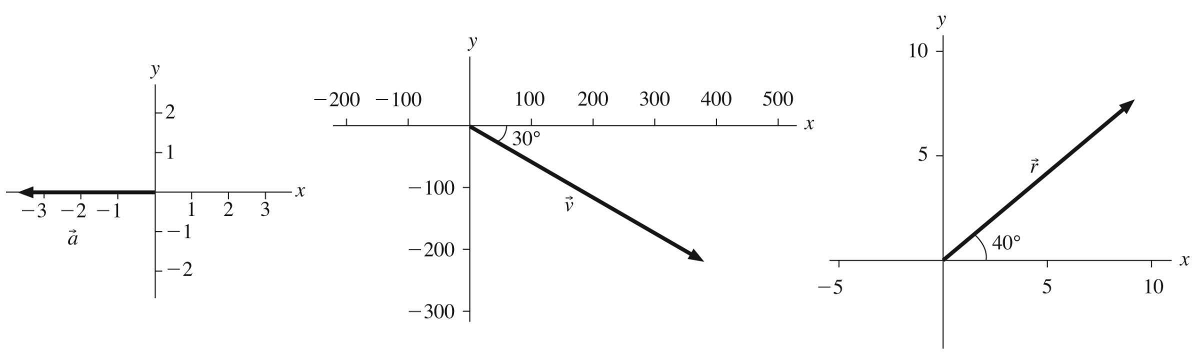
CQ 3.2. It is possible that $C = A + B$ only if $\vec{A}$ and $\vec{B}$ both point in the same direction as in the figure below. It is not possible that $C > A + B$ because, if $\vec{A}$ and $\vec{B}$ point in different directions, putting them tip to tail gives a resultant with a shorter length (see figure below).



CQ 3.3. It is possible that $C = 0$ if $\vec{A} = -\vec{B}$. It is not possible for the length of a vector to be negative, so $C \geq 0$. Even if $\vec{A}$ and $\vec{B}$ are parallel but in opposite directions, $\vec{C}$ will still have a length greater than or equal to zero.

CQ 3.9. **(a)** False, because the size of a vector is fixed. **(b)** False, because the direction of a vector in space is independent of any coordinate system. **(c)** True, because the orientation of the vector relative to the axes can be different.

3.6. Visualize:



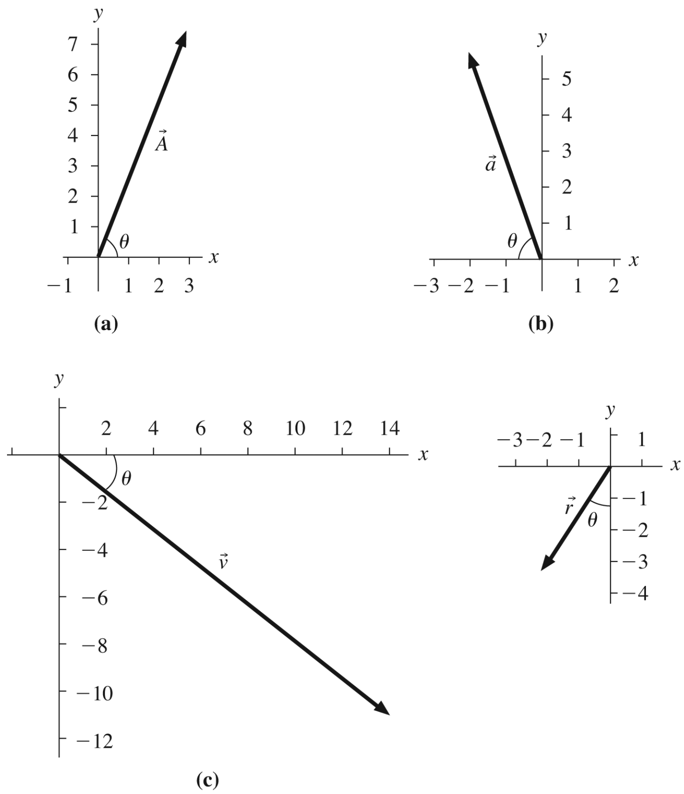
(a) (b) (c)

Solve: (a) $a_x = -3.5\ \text{m/s}^2$; $a_y = 0\ \text{m/s}^2$

(b) $v_x = (440\ \text{m/s})(\cos 30°) = 380\ \text{m/s}$; $v_y = -(440\ \text{m/s})(\sin 30°) = -220\ \text{m/s}$

(c) $r_x = (12\ \text{m})(\cos 40°) = 9.2\ \text{m}$; $r_y = (12\ \text{m})(\sin 40°) = 7.7\ \text{m}$

3.11. Visualize:



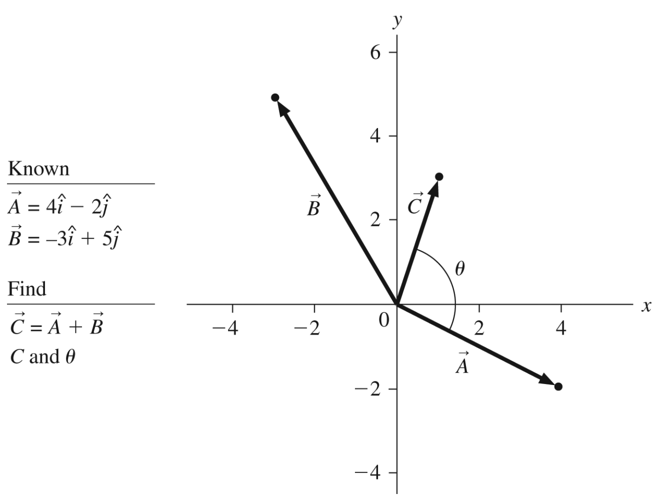
Solve: (a) $A = \sqrt{(3.0)^2 + (7.0)^2} = 7.6, \quad \theta = 67°$

(b) $a = \sqrt{(-2.0\ \text{m/s}^2)^2 + (4.5\ \text{m/s}^2)^2} = 4.9\ \text{m/s}^2, \quad \theta = 66°$

(c) $v = \sqrt{(14\ \text{m/s})^2 + (-11\ \text{m/s})^2} = 18\ \text{m/s}, \quad \theta = 38°$

(d) $r = \sqrt{(-2.2\ \text{m})^2 + (-3.3\ \text{m})^2} = 4.0\ \text{m}, \quad \theta = 34°$

3.13. Visualize: The vectors $\vec{A}$, $\vec{B}$, and $\vec{C} = \vec{A} + \vec{B}$ are shown.



Solve: (a) We have $\vec{A} = 4\hat{i} - 2\hat{j}$ and $\vec{B} = -3\hat{i} + 5\hat{j}$. Thus, $\vec{C} = \vec{A} + \vec{B} = (4\hat{i} - 2\hat{j}) + (-3\hat{i} + 5\hat{j}) = 1\hat{i} + 3\hat{j}$.

(b) Vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ are shown in the figure above.

(c) Since $\vec{C} = 1\hat{i} + 3\hat{j} = C_x\hat{i} + C_y\hat{j}$, $C_x = 1$, and $C_y = 3$. Therefore, the magnitude and direction of $\vec{C}$ are $C = \sqrt{(1)^2 + (3)^2} = \sqrt{10} = 3.2$ and $\theta = \tan^{-1}(C_y/C_x) = \tan^{-1}(3/1) = 72°$, respectively.

Assess: The vector $\vec{C}$ is to the right and up, thus implying that both the x and y components are positive. Also $\theta > 45°$ since $|C_y| > |C_x|$.

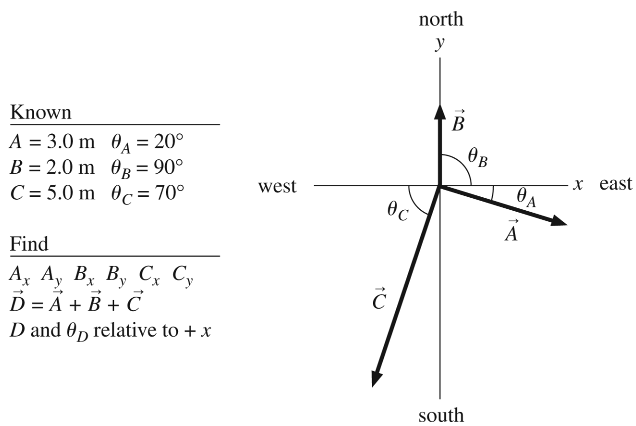
3.17. Solve: We have $\vec{E} = E_x\hat{i} + E_y\hat{j} = 2\hat{i} + 3\hat{j}$, which means $E_x = 2$ and $E_y = 3$. Also, $\vec{F} = F_x\hat{i} + F_y\hat{j} = 2\hat{i} - 2\hat{j}$, which means $F_x = 2$ and $F_y =$ 2 2.

(a) The magnitude of $\vec{E}$ is given by $E = \sqrt{E_x^2 + E_y^2} = \sqrt{(2)^2 + (3)^2} = 3.6$ and the magnitude of $\vec{F}$ is given by $F = \sqrt{F_x^2 + F_y^2} = \sqrt{(2)^2 + (2)^2} = 2.8$.

(b) Since $\vec{E} + \vec{F} = 4\hat{i} + 1\hat{j}$, the magnitude of $\vec{E} + \vec{F}$ is $\sqrt{(4)^2 + (1)^2} = 4.1$.

(c) Since $-\vec{E} - 2\vec{F} = -(2\hat{i} + 3\hat{j}) - 2(2\hat{i} - 2\hat{j}) = -6\hat{i} + 1\hat{j}$, the magnitude of $-\vec{E} - 2\vec{F}$ is $\sqrt{(-6)^2 + (1)^2} = 6.1$.

3.22. Visualize: (a)



Solve: (b) The components of the vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ are

$A_x = (3.0\text{ m})\cos(20°) = 2.8\text{ m}$ and $A_y = -(3.0\text{ m})\sin(20°) = -1.0\text{ m}$; $B_x = 0\text{ m}$ and $B_y = 2.0\text{ m}$;

$C_x = -(5.0\text{ m})\cos(70°) = -1.7\text{ m}$ and $C_y = -(5.0\text{ m})\sin(70°) = -4.7\text{ m}$. This means the vectors can be written as

$$\vec{A} = (2.8\hat{i} + 1.0\hat{j})\text{ m}, \quad \vec{B} = (2.0\hat{j})\text{ m}, \quad \vec{C} = (-1.7\hat{i} - 4.7\hat{j})\text{ m}$$

(c) We have $\vec{D} = \vec{A} + \vec{B} + \vec{C} = (1.1\text{ m})\hat{i} - (3.7\text{ m})\hat{j}$. This means

$$D = \sqrt{(1.1\text{ m})^2 + (3.7\text{ m})^2} = 3.9\text{ m} \qquad \theta = \tan^{-1}(3.9/1.09) = 74°$$

The direction of $\vec{D}$ is south of east, 74° below the $+x$-axis.

3.23. Solve: We have $\vec{r} = (5.0\hat{i} + 4.0\hat{j})t^2$ m. This means that $\vec{r}$ does not change the ratio of its components as t increases; that is, the direction of $\vec{r}$ is constant. The magnitude of $\vec{r}$ is given by $r = \sqrt{(5.0t^2)^2 + (4.0t^2)^2}\text{ m} = 6.40t^2$ m.

(a) The particle's distance from the origin at $t = 0$ s, $t = 2$ s, and $t = 5$ s is 0 m, 26 m, and 160 m.

(b) The particle's velocity is $\vec{v}(t) = \dfrac{d\vec{r}}{dt} = (5.0\hat{i} + 4.0\hat{j})\dfrac{dt^2}{dt}\text{ m/s} = (5.0\hat{i} + 4.0\hat{j})2t\text{ m/s} = (10\hat{i} + 8.0\hat{j})t\text{ m/s}$.

(c) The magnitude of the particle's velocity is given by $v = \sqrt{(10t)^2 + (8.0t)^2} = 13t$ m/s. The particle's speed at t = 0 s, t = 2 s, and t = 5 s is 0 m/s, 26 m/s, and 64 m/s.

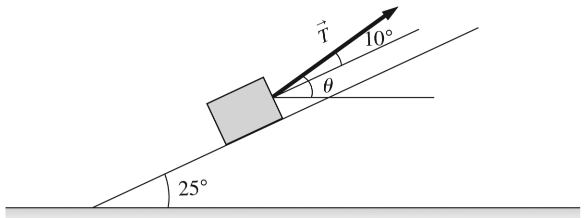
3.25. Visualize: Refer to Figure P3.25 in your textbook.

Solve: From the rules of trigonometry, we have $A_x = (4\text{ m})\cos(60°) = 2.0\text{ m}$ and $A_y = (4\text{ m})\sin(60°) = 3.5\text{ m}$. Also, $B_x = -(3\text{ m})\cos(20°) = -2.8$ and $B_y = +(3\text{ m})\sin(20°) = 1.0\text{ m}$. Since $\vec{A} + \vec{B} + \vec{C} = \vec{0}$,

$\vec{C} = -\vec{A} - \vec{B} = (-\vec{A}) + (-\vec{B}) = (-2.0\hat{\imath} - 3.5\hat{\jmath}) + (+2.8\hat{\imath} - 1.0\hat{\jmath}) = 0.8\hat{\imath} - 4.5\hat{\jmath}$.

3.38. Model: Model the crate as a particle.

Visualize:



Known
$T = 550$ N
$\theta = 25° + 10° = 35°$
Find
T_x
T_y

Solve: First find the angle from the horizontal: $\theta = 25° + 10° = 35°$.

$$T_x = (550\text{ N})\cos 35° = 450\text{ N} \qquad T_y = (550\text{ N})\sin 35° = 310\text{ N}$$

Assess: The horizontal component of the tension would decrease if the angle of the ramp decreases or if the angle of the rope from the ramp decreases.

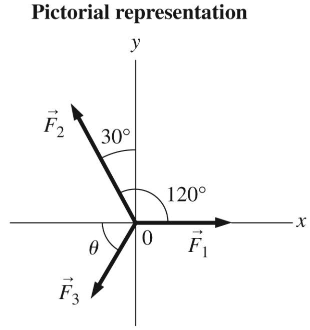
3.43. Model: We will treat the knot in the rope as a particle in static equilibrium.

Visualize:

Pictorial representation

Known
$F_1 = 3.0$ units
$F_2 = 5.0$ units

Find
F_3 and θ



Solve: Expressing the vectors in component form, we have $\vec{F}_1 = 3.0\hat{\imath}$ and $\vec{F}_2 = -5.0\sin(30°)\hat{\imath} + 5.0\cos(30°)\hat{\jmath}$. Since we must have $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}$ for the know to remain stationary, we can write $\vec{F}_3 = 2\,\vec{F}_1 - \vec{F}_2 = -0.50\,\hat{\imath} - 4.33\hat{\jmath}$. The magnitude of $\vec{F}_3$ is given by $F_3 = \sqrt{(-0.50)^2 + (-4.33)^2} = 4.4$ units The angle between $\vec{F}_3$ and the negative x-axis is $\theta = \tan^{-1}(4.33/0.50) = 83°$ below the negative x-axis.

Assess: The resultant vector has both components negative, and is therefore in quadrant III. Its magnitude and direction are reasonable. Note the minus sign that we have manually inserted with the force $\vec{F}_2$.