(M7) $\underline{A} = 4\underline{i} + 3\underline{j} + 3.32\underline{k}$ N
$\underline{B} = 2\underline{i} + 1.5\underline{j} + 3.12\underline{k}$ m

(a) $\underline{A}.\underline{B} = A_xB_x + A_yB_y + A_zB_z = (4)(2) + (3)(1.5) + (3.32)(3.12) = 22.86$ Nm

(b) $A = [(4)^2 + (3)^2 + (3.32)^2]^{1/2} = 6.0$
$B = [(2)^2 + (1.5)^2 + (3.12)^2]^{1/2} = 4.0$
$\underline{A}.\underline{B} = AB\cos\theta = 22.86$
$\therefore \cos\theta = 22.86/24$
$\theta = 17.7^0$

(c) Magnitude of $\underline{A}x\underline{B}$ is $AB\sin\theta = (6)(4)\sin(17.7^0)$
$= 7.3$ Nm

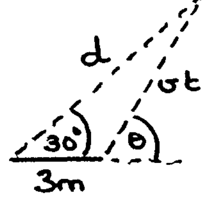
(M8)(i) $x = A\sin\omega t + Bt$
$y = A\cos\omega t + A$
where A, B, and ω are constants.
Velocity is given by $\underline{v} = (dx/dt, dy/dt)$
$= (A\omega\cos\omega t + B, -A\omega\sin\omega t)$
Acceleration is given by $\underline{a} = (dv_x/dt, dv_y/dt)$
$= (-A\omega^2\sin\omega t, -A\omega^2\cos\omega t)$

(ii) When y is a maximum, $\cos\omega t$ must equal 1, so $\sin\omega t = 0$.
$\therefore \underline{v} = (A\omega+B, 0)$
$\underline{a} = (0, -A\omega^2)$

When y is a minimum, $\cos\omega t$ must equal -1, and again $\sin\omega t = 0$.
$\therefore \underline{v} = (-A\omega+B, 0)$
$\underline{a} = (0, A\omega^2)$

(M14) 12 m/s at elevation of 40^0
$\therefore u_x = 12\cos(40^0) = 9.19$ m/s, $u_y = 12\sin(40^0) = 7.71$ m/s

Time to return to the same height given by $s_y = u_yt - gt^2/2$
$0 = 7.71t - 4.905t^2$
$t = 1.57$ s



$d = 1.57(9.19) = 14.4$ m

$d\cos(30^0) = 3 + vt\cos\theta \quad \therefore 1.57v\cos\theta = 9.51$
$d\sin(30^0) = vt\sin\theta \quad \therefore 1.57v\sin\theta = 7.2$
$\therefore \tan\theta = 7.2/9.51, \ \theta = 37^0$
$v = 9.51/(1.57\cos\theta)) = 7.6$ m/s

3-38. Using the fact that

$$\hat{\mathrm{i}} \times \hat{\mathrm{j}} = \hat{\mathrm{k}}, \quad \hat{\mathrm{j}} \times \hat{\mathrm{k}} = \hat{\mathrm{i}}, \quad \hat{\mathrm{k}} \times \hat{\mathrm{i}} = \hat{\mathrm{j}}$$

we obtain

$$2\vec{A} \times \vec{B} = 2\left(2.00\hat{\mathrm{i}} + 3.00\hat{\mathrm{j}} - 4.00\hat{\mathrm{k}}\right) \times \left(-3.00\hat{\mathrm{i}} + 4.00\hat{\mathrm{j}} + 2.00\hat{\mathrm{k}}\right) = 44.0\hat{\mathrm{i}} + 16.0\hat{\mathrm{j}} + 34.0\hat{\mathrm{k}}.$$

Next, making use of

$$\hat{\mathrm{i}} \cdot \hat{\mathrm{i}} = \hat{\mathrm{j}} \cdot \hat{\mathrm{j}} = \hat{\mathrm{k}} \cdot \hat{\mathrm{k}} = 1$$
$$\hat{\mathrm{i}} \cdot \hat{\mathrm{j}} = \hat{\mathrm{j}} \cdot \hat{\mathrm{k}} = \hat{\mathrm{k}} \cdot \hat{\mathrm{i}} = 0$$

we have

$$3\vec{C} \cdot \left(2\vec{A} \times \vec{B}\right) = 3\left(7.00\hat{\mathrm{i}} - 8.00\hat{\mathrm{j}}\right) \cdot \left(44.0\hat{\mathrm{i}} + 16.0\hat{\mathrm{j}} + 34.0\hat{\mathrm{k}}\right)$$
$$= 3[(7.00)(44.0) + (-8.00)(16.0) + (0)(34.0)] = 540.$$

3-43. From the figure, we note that $\vec{c} \perp \vec{b}$, which implies that the angle between $\vec{c}$ and the $+x$ axis is $\theta + 90°$. In unit-vector notation, the three vectors can be written as

$$\vec{a} = a_x\hat{\mathrm{i}}$$
$$\vec{b} = b_x\hat{\mathrm{i}} + b_y\hat{\mathrm{j}} = (b\cos\theta)\hat{\mathrm{i}} + (b\sin\theta)\hat{\mathrm{j}}$$
$$\vec{c} = c_x\hat{\mathrm{i}} + c_y\hat{\mathrm{j}} = [c\cos(\theta + 90°)]\hat{\mathrm{i}} + [c\sin(\theta + 90°)]\hat{\mathrm{j}}$$

The above expressions allow us to evaluate the components of the vectors.

(a) The x-component of $\vec{a}$ is $a_x = a \cos 0° = a = 3.00$ m.

(b) Similarly, the y-componnet of $\vec{a}$ is $a_y = a \sin 0° = 0$.

(c) The x-component of $\vec{b}$ is $b_x = b \cos 30° = (4.00 \text{ m}) \cos 30° = 3.46$ m,

(d) and the y-component is $b_y = b \sin 30° = (4.00 \text{ m}) \sin 30° = 2.00$ m.

(e) The x-component of $\vec{c}$ is $c_x = c \cos 120° = (10.0 \text{ m}) \cos 120° = -5.00$ m,

(f) and the y-component is $c_y = c \sin 30° = (10.0 \text{ m}) \sin 120° = 8.66$ m.

(g) The fact that $\vec{c} = p\vec{a} + q\vec{b}$ implies

$$\vec{c} = c_x\hat{\mathrm{i}} + c_y\hat{\mathrm{j}} = p(a_x\hat{\mathrm{i}}) + q(b_x\hat{\mathrm{i}} + b_y\hat{\mathrm{j}}) = (pa_x + qb_x)\hat{\mathrm{i}} + qb_y\hat{\mathrm{j}}$$

or

$$c_x = pa_x + qb_x, \qquad c_y = qb_y$$

Substituting the values found above, we have

$$-5.00 \text{ m} = p\,(3.00 \text{ m}) + q\,(3.46 \text{ m})$$
$$8.66 \text{ m} = q\,(2.00 \text{ m}).$$

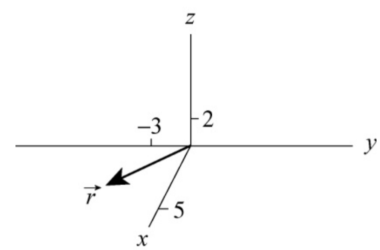
Solving these equations, we find $p = -6.67$.

(h) Similarly, $q = 4.33$ (note that it's easiest to solve for q first). The numbers p and q have no units.

4-8. Our coordinate system has $\hat{\text{i}}$ pointed east and $\hat{\text{j}}$ pointed north. The first displacement is $\vec{r}_{AB} = (483 \text{ km})\hat{\text{i}}$ and the second is $\vec{r}_{BC} = (-966 \text{ km})\hat{\text{j}}$.

(a) The net displacement is

$$\vec{r}_{AC} = \vec{r}_{AB} + \vec{r}_{BC} = (483 \text{ km})\hat{\text{i}} - (966 \text{ km})\hat{\text{j}}$$



which yields $|\vec{r}_{AC}| = \sqrt{(483 \text{ km})^2 + (-966 \text{ km})^2} = 1.08 \times 10^3 \text{ km}$.

(b) The angle is given by

$$\theta = \tan^{-1}\left(\frac{-966 \text{ km}}{483 \text{ km}}\right) = -63.4°.$$

We observe that the angle can be alternatively expressed as 63.4° south of east, or 26.6° east of south.

(c) Dividing the magnitude of $\vec{r}_{AC}$ by the total time (2.25 h) gives

$$\vec{v}_{\text{avg}} = \frac{(483 \text{ km})\hat{\text{i}} - (966 \text{ km})\hat{\text{j}}}{2.25 \text{ h}} = (215 \text{ km/h})\hat{\text{i}} - (429 \text{ km/h})\hat{\text{j}}$$

with a magnitude $|\vec{v}_{\text{avg}}| = \sqrt{(215 \text{ km/h})^2 + (-429 \text{ km/h})^2} = 480 \text{ km/h}$.

(d) The direction of $\vec{v}_{\text{avg}}$ is 26.6° east of south, same as in part (b). In magnitude-angle notation, we would have $\vec{v}_{\text{avg}} = (480 \text{ km/h} \angle -63.4°)$.

(e) Assuming the AB trip was a straight one, and similarly for the BC trip, then $|\vec{r}_{AB}|$ is the distance traveled during the AB trip, and $|\vec{r}_{BC}|$ is the distance traveled during the BC trip. Since the average speed is the total distance divided by the total time, it equals

$$\frac{483\text{ km} + 966\text{ km}}{2.25\text{ h}} = 644\text{ km/h}.$$

4-27. We adopt the positive direction choices used in the textbook so that equations such as Eq. 4-22 are directly applicable. The coordinate origin is at ground level directly below the release point. We write θ_0 = –30.0° since the angle shown in the figure is measured clockwise from horizontal. We note that the initial speed of the decoy is the plane's speed at the moment of release: v_0 = 290 km/h, which we convert to SI units: (290)(1000/3600) = 80.6 m/s.

(a) We use Eq. 4-12 to solve for the time:

$$\Delta x = (v_0 \cos\theta_0)\ t \quad \Rightarrow \quad t = \frac{700\text{ m}}{(80.6\text{ m/s})\cos(-30.0°)} = 10.0\text{ s}.$$

(b) And we use Eq. 4-22 to solve for the initial height y_0:

$$y - y_0 = (v_0 \sin\theta_0)\ t - \frac{1}{2}gt^2 \quad \Rightarrow \quad 0 - y_0 = (-40.3\text{ m/s})(10.0\text{ s}) - \frac{1}{2}(9.80\text{ m/s}^2)(10.0\text{ s})^2$$

which yields y_0 = 897 m.

4-32. We adopt the positive direction choices used in the textbook so that equations such as Eq. 4-22 are directly applicable. The coordinate origin is at the release point (the initial position for the ball as it begins projectile motion in the sense of §4-5), and we let θ_0 be the angle of throw (shown in the figure). Since the horizontal component of the velocity of the ball is $v_x = v_0 \cos 40.0°$, the time it takes for the ball to hit the wall is

$$t = \frac{\Delta x}{v_x} = \frac{22.0\text{ m}}{(25.0\text{ m/s})\cos 40.0°} = 1.15\text{ s}.$$

(a) The vertical distance is

$$\Delta y = (v_0 \sin\theta_0)t - \frac{1}{2}gt^2 = (25.0\text{ m/s})\sin 40.0°(1.15\text{ s}) - \frac{1}{2}(9.80\text{ m/s}^2)(1.15\text{ s})^2 = 12.0\text{ m}.$$

(b) The horizontal component of the velocity when it strikes the wall does not change from its initial value: $v_x = v_0 \cos 40.0°$ = 19.2 m/s.

(c) The vertical component becomes (using Eq. 4-23)

$$v_y = v_0 \sin\theta_0 - gt = (25.0 \text{ m/s}) \sin 40.0° - (9.80 \text{ m/s}^2)(1.15 \text{ s}) = 4.80 \text{ m/s}.$$

(d) Since $v_y > 0$ when the ball hits the wall, it has not reached the highest point yet.