1. SerPSE7 4.P.005

$$\mathbf{v}_i = \left(4.00\hat{\mathbf{i}} + 1.00\hat{\mathbf{j}}\right) \text{ m/s and } \mathbf{v}(20.0) = \left(20.0\hat{\mathbf{i}} - 5.00\hat{\mathbf{j}}\right) \text{ m/s}$$

(a)

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{20.0 - 4.00}{20.0} \text{ m/s}^2 = \boxed{0.800 \text{ m/s}^2}$$

$$a_y = \frac{\Delta v_y}{\Delta t} = \frac{-5.00 - 1.00}{20.0} \text{ m/s}^2 = \boxed{-0.300 \text{ m/s}^2}$$

(b)

$$\theta = \tan^{-1}\left(\frac{-0.300}{0.800}\right) = -20.6° = \boxed{339° \text{ from } +x \text{ axis}}$$

(c) At $t = 25.0$ s

$$x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2 = 10.0 + 4.00(25.0) + \frac{1}{2}(0.800)(25.0)^2 = \boxed{360 \text{ m}}$$

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2 = -4.00 + 1.00(25.0) + \frac{1}{2}(-0.300)(25.0)^2 = \boxed{-72.7 \text{ m}}$$

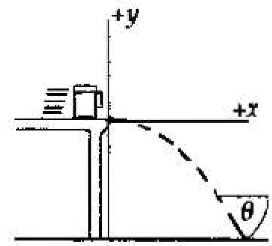
$$v_{xf} = v_{xi} + a_x t = 4 + 0.8(25) = 24 \text{ m/s}$$

$$v_{yf} = v_{yi} + a_y t = 1 - 0.3(25) = -6.5 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{-6.50}{24.0}\right) = \boxed{-15.2°}$$

2. SerPSE7 4.P.009

(a) The mug leaves the counter horizontally with a velocity v_{xi} (say). If time t elapses before it hits the ground, then since there is no horizontal acceleration, $x_f = v_{xi}t$, i.e.,



$$t = \frac{x_f}{v_{xi}} = \frac{(1.40\text{ m})}{v_{xi}}$$

In the same time it falls a distance of 0.860 m with acceleration downward of 9.80 m/s^2. Then

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2:\ 0 = 0.860\text{ m} + \frac{1}{2}\left(-9.80\text{ m/s}^2\right)\left(\frac{1.40\text{ m}}{v_{xi}}\right)^2.$$

Thus,

$$v_{xi} = \sqrt{\frac{\left(4.90\text{ m/s}^2\right)\left(1.96\text{ m}^2\right)}{0.860\text{ m}}} = \boxed{3.34\text{ m/s}}.$$

(b) The vertical velocity component with which it hits the floor is

$$v_{yf} = v_{yi} + a_y t = 0 + \left(-9.80\text{ m/s}^2\right)\left(\frac{1.40\text{ m}}{3.34\text{ m/s}}\right) = -4.11\text{ m/s}.$$

Hence, the angle θ at which the mug strikes the floor is given by

$$\theta = \tan^{-1}\left(\frac{v_{yf}}{v_{xf}}\right) = \tan^{-1}\left(\frac{-4.11}{3.34}\right) = \boxed{-50.9°}.$$

3. SerPSE7 4.P.014

The horizontal component of displacement is $x_f = v_{xi}t = (v_i \cos\theta_i)t$. Therefore, the time required to reach the building a distance d away is $t = \dfrac{d}{v_i \cos\theta_i}$. At this time, the altitude of the water is

$$y_f = v_{yi}t + \frac{1}{2}a_y t^2 = v_i \sin\theta_i\left(\frac{d}{v_i\cos\theta_i}\right) - \frac{g}{2}\left(\frac{d}{v_i\cos\theta_i}\right)^2.$$

Therefore the water strikes the building at a height h above ground level of

$$h = y_f = \boxed{d\tan\theta_i - \frac{gd^2}{2v_i^2\cos^2\theta_i}}.$$

4. SerPSE7 4.P.021

The horizontal kick gives zero vertical velocity to the rock. Then its time of flight follows from

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2$$
$$-40.0\ \text{m} = 0 + 0 + \frac{1}{2}\left(-9.80\ \text{m/s}^2\right)t^2$$
$$t = 2.86\ \text{s}.$$

The extra time $3.00\ \text{s} - 2.86\ \text{s} = 0.143\ \text{s}$ is the time required for the sound she hears to travel straight back to the player.

It covers distance

$$(343\ \text{m/s})0.143\ \text{s} = 49.0\ \text{m} = \sqrt{x^2 + (40.0\ \text{m})^2}$$

where x represents the horizontal distance the rock travels.

$$x = 28.3\ \text{m} = v_{xi}t + 0t^2$$
$$\therefore v_{xi} = \frac{28.3\ \text{m}}{2.86\ \text{s}} = \boxed{9.91\ \text{m/s}}$$

5. SerPSE7 4.P.034.

(a)

$$\mathbf{v}_H = 0 + \mathbf{a}_H t = \left(3.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}}\right)\ \text{m/s}^2\,(5.00\ \text{s})$$

$$\mathbf{v}_H = \left(15.0\hat{\mathbf{i}} - 10.0\hat{\mathbf{j}}\right)\ \text{m/s}$$

$$\mathbf{v}_J = 0 + \mathbf{a}_j t = \left(1.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}}\right)\ \text{m/s}^2\,(5.00\ \text{s})$$

$$\mathbf{v}_J = \left(5.00\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}}\right)\ \text{m/s}$$

$$\mathbf{v}_{HJ} = v_H - v_J = \left(15.0\hat{\mathbf{i}} - 10.0\hat{\mathbf{j}} - 5.00\hat{\mathbf{i}} - 15.0\hat{\mathbf{j}}\right)\ \text{m/s}$$

$$\mathbf{v}_{HJ} = \left(10.0\hat{\mathbf{i}} - 25.0\hat{\mathbf{j}}\right)\ \text{m/s}$$

$$\left|\mathbf{v}_{HJ}\right| = \sqrt{(10.0)^2 + (25.0)^2}\ \text{m/s} = \boxed{26.9\ \text{m/s}}$$

(b)

$$\mathbf{r}_H = 0 + 0 + \frac{1}{2}\mathbf{a}_H t^2 = \frac{1}{2}\left(3.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}}\right)\ \text{m/s}^2\,(5.00\ \text{s})^2$$

$$\mathbf{r}_H = \left(37.5\hat{\mathbf{i}} - 25.0\hat{\mathbf{j}}\right)\ \text{m}$$

$$\mathbf{r}_J = \frac{1}{2}\left(1.00\hat{\mathbf{i}} + 3.00\hat{\mathbf{j}}\right)\ \text{m/s}^2\,(5.00\text{s})^2 = \left(12.5\hat{\mathbf{i}} + 37.5\hat{\mathbf{j}}\right)\ \text{m}$$

$$\mathbf{r}_{HJ} = \mathbf{r}_H - \mathbf{r}_J = \left(37.5\hat{\mathbf{i}} - 25.0\hat{\mathbf{j}} - 12.5\hat{\mathbf{i}} - 37.5\hat{\mathbf{j}}\right)\ \text{m}$$

$$\mathbf{r}_{HJ} = \left(25.0\hat{\mathbf{i}} - 62.5\hat{\mathbf{j}}\right)\ \text{m}$$

$$\left|\mathbf{r}_{HJ}\right| = \sqrt{(25.0)^2 + (62.5)^2}\ \text{m} = \boxed{67.3\ \text{m}}$$

(c)

$$\mathbf{a}_{HJ} = \mathbf{a}_H - \mathbf{a}_J = \left(3.00\hat{\mathbf{i}} - 2.00\hat{\mathbf{j}} - 1.00\hat{\mathbf{i}} - 3.00\hat{\mathbf{j}}\right)\ \text{m/s}^2$$

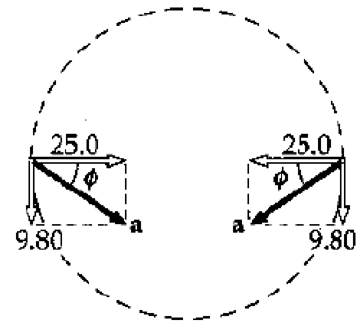
$$\mathbf{a}_{HJ} = \boxed{\left(2.00\hat{\mathbf{i}} - 5.00\hat{\mathbf{j}}\right)\ \text{m/s}^2}$$

6. SerPSE7 4.P.047.

(a) $a_c = \frac{v^2}{r} = \frac{(5.00\ \text{m/s})^2}{1.00\ \text{m}} = \boxed{25.0\ \text{m/s}^2}$

$a_t = g = \boxed{9.80\ \text{m/s}^2}$

(b) See figure to the right.

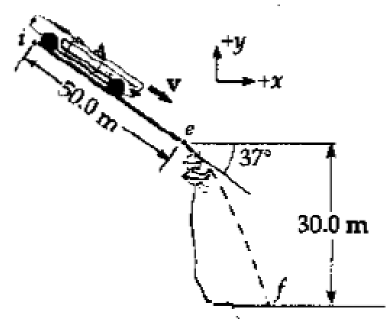


(c) $a = \sqrt{a_c^2 + a_t^2} = \sqrt{(25.0\ \text{m/s}^2)^2 + (9.80\ \text{m/s}^2)^2} = \boxed{26.8\ \text{m/s}^2}$

$\phi = \tan^{-1}\left(\frac{a_t}{a_c}\right) = \tan^{-1}\frac{9.80\ \text{m/s}^2}{25.0\ \text{m/s}^2} = \boxed{21.4°}$

7. SerPSE7 4.P.057.

(a) While on the incline



$$v_f^2 - v_i^2 = 2a\Delta x$$
$$v_f - v_i = at$$
$$v_f^2 - 0 = 2(4.00)(50.0)$$
$$20.0 - 0 = 4.00t$$
$$v_f = \boxed{20.0\ \text{m/s}}$$
$$t = \boxed{5.00\ \text{s}}$$

(b) Initial free-flight conditions give us

$$v_{xi} = 20.0\cos 37.0° = 16.0\ \text{m/s}$$

and

$$v_{yi} = -20.0\sin 37.0° = -12.0\ \text{m/s}$$
$$v_{xf} = v_{xi} \text{ since } a_x = 0$$
$$v_{yf} = -\sqrt{2a_y\Delta y + v_{yi}^2} = -\sqrt{2(-9.80)(-30.0) + (-12.0)^2} = -27.1\ \text{m/s}$$
$$v_f = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{(16.0)^2 + (-27.1)^2} = \boxed{31.5\ \text{m/s at } 59.4° \text{ below the horizontal}}$$

(c) $t_1 = 5\ \text{s};\ t_2 = \dfrac{v_{yf} - v_{yi}}{a_y} = \dfrac{-27.1 + 12.0}{-9.80} = 1.53\ \text{s}$

$$t = t_1 + t_2 = \boxed{6.53\ \text{s}}$$

(d) $\Delta x = v_{xi}t_1 = 16.0(1.53) = \boxed{24.5\ \text{m}}$