0.0.1 Homework

5. A train at a constant 60.0 km/h moves east for 40.0 min, then in a direction 50.0° east of due north for 20.0 min, and then west for 50.0 min. What are the (a) magnitude and (b) angle of its average velocity during this trip?

$$\begin{aligned}
&= 40\hat{\imath} + 20cos(40)\hat{\imath} + 20sin(40)\hat{\jmath} - 50\hat{\imath} \\
&= 5.32089\hat{\imath} + 12.8558\hat{\jmath} \\
&= \boxed{13.9077m/s, \theta = 67.51°\text{N of E}}
\end{aligned}$$

21. A dart is thrown horizontally with an initial speed of 10 m/s toward point P, the bull's-eye on a dart board. It hits at point Q on the rim, vertically below P, 0.19 s later. (a) What is the distance PQ? (b) How far away from the dart board is the dart released?

a) Solving for $\hat{\imath}$ component we get $10 \cdot 0.19 = 1.9m$, then solving for $\hat{\jmath}$ we get

$$\Delta x = \frac{1}{2}at^2 = \frac{1}{2}(-9.8)(0.19)^2 = -0.17689$$

So the distance $\vec{PQ} = |-0.17689| = \boxed{0.17689m}$
b) Then, the distance $\vec{PQ}$ must be $\sqrt{0.17689^2 + 1.9^2} = \boxed{1.90822m}$

23. A projectile is fired horizontally from a gun that is 45.0 m above flat ground, emerging from the gun with a speed of 250 m/s. (a) How long does the projectile remain in the air? (b) At what horizontal distance from the firing point does it strike the ground? (c) What is the magnitude of the vertical component of its velocity as it strikes the ground?

a)

$$\Delta x = -45 = \frac{1}{2}at^2 = \frac{1}{2}(-9.8)t^2$$
$$t = \pm 3.0305$$

, so the projectile must remain $\boxed{3.0305}$ seconds in the air.
b) $3.0305 \cdot 250 = \boxed{757.625m}$
c) $v = v_0 + at$ and $v_0 = 0, a = 9.8, t = 3.0305$, so

$$v = -9.8 \cdot 3.0305 = \boxed{-29.6989m/s}$$

25. The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 12.0° to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, determine his take-off speed.

$$77 = \frac{v_0^2 \sin(2\theta)}{g}$$

$$\boxed{v = 43.0727m/s}$$

27. A certain airplane has a speed of 290.0 km/h and is diving at an angle of 30.0° below the horizontal when the pilot releases a radar decoy (Fig. 4-33). The horizontal distance between the release point and the point where the decoy strikes the ground is $d = 700m$. (a) How long is the decoy in the air? (b) How high was the release point?
a) $d = 700m$, so then the it must take the horizontal component $\frac{700}{290\cos(30°)} = \boxed{2.787}$ seconds.
b) $v_0 = -290\sin(30°) = -145$

$$\Delta y = -145t + \frac{1}{2}at^2$$

$$\Delta y = -145(2.787) + \frac{1}{2}(-9.8)(2.787)^2 = \boxed{-442.175m}$$

28. In Fig. 4-34, a stone is projected at a cliff of height h with an initial speed of 42.0 m/s directed at angle u0 60.0° above the horizontal. The stone strikes at A, 5.50 s after launching. Find (a) the height h of the cliff, (b) the speed of the stone just before impact at A, and (c) the maximum height H reached above the ground.

$$r(t) = (42\cos(60^\circ)t)\hat{\imath} + (h - 42\sin(60^\circ)t - \frac{1}{2}(9.8)t^2)\hat{\jmath}$$

a)

$$42\sin(60^\circ)t - \frac{1}{2}(9.8)t^2 = h$$

$$42\sin(60^\circ)(5.50) - \frac{1}{2}(9.8)(5.50)^2 = h$$

$$\boxed{h = 51.8269m}$$

b)

$$v_x(5.50) = 42\cos(60^\circ) = 21, v_y(5.50) = 42\sin(60^\circ) - 9.8(5.5) = -17.52$$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{21^2 + 17.52^2} = \boxed{27.34m/s}$$

c)

$$0 = v_0^2 + 2a\Delta y = (42\sin(60^\circ))^2 - 2(9.8)\Delta y$$

$$\boxed{\Delta y = 67.5m}$$

29. A projectile's launch speed is five times its speed at maximum height. Find launch angle θ_0.

This problem is trivial:

$$v_0 = 5 \cdot v_{\max}$$

$$v_0 = 5v_0 cos(\theta)$$

Divide both sides by $5v_0$, and we get $\frac{1}{5} = cos(\theta)$, so

$$cos^{-1}\left(\frac{1}{5}\right) = \boxed{78.463^\circ}$$

39. n Fig. 4-37, a ball is thrown leftward from the left edge of the roof, at height h above the ground. The ball hits the ground 1.50 s later, at distance d = 25.0 m from the building and at angle u = 60.0° with the horizontal. (a) Find h. (Hint: One way is to reverse the motion, as if on video.) What are the (b) magnitude and (c) angle relative to the horizontal of the velocity at which the ball is thrown? (d) Is the angle above or below the horizontal?

a) $h = \frac{1}{2}(9.8)t^2$ and $t = 1.5$, so $h = \boxed{0.5(9.8)(1.5)^2 = 11.025m}$

b) If $d = 25$ and $t = 1.5$, then $v_x = \frac{25}{1.5} = 16.66m/s$, and $r_y = \frac{1}{2}(9.8)(1.5)^2 = 11.025m/s$

$$\sqrt{v_x^2 + v_y^2} = \sqrt{16.66^2 + 11.025^2} = \boxed{19.9776m/s}$$

c)

$$\arctan\left(\frac{v_y}{v_x}\right) = \arctan\left(\frac{11.025}{16.66}\right) = \boxed{33.5^\circ}$$

d) The angle is above the horizontal.