Problem # 1

39. T A point is located in a polar coordinate system by the coordinates $r = 2.5$ m and $\theta = 35°$. Find the x- and y-coordinates of this point, assuming that the two coordinate systems have the same origin.

Problem # 2

45. T For the triangle shown in Figure P1.45, what are (a) the length of the unknown side, (b) the tangent of θ, and (c) the sine of ϕ?

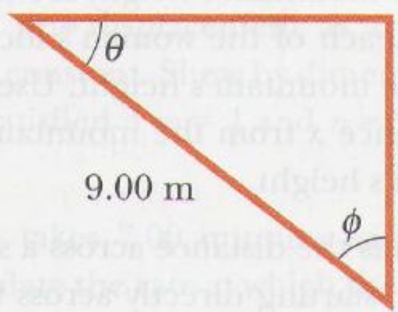


Figure P1.45

Problem # 3

1. If the velocity of a particle is nonzero, can the particle's acceleration be zero? Explain.

Problem # 4

2. If the velocity of a particle is zero, can the particle's acceleration be nonzero? Explain.

Problem # 5

1. BIO The speed of a nerve impulse in the human body is about 100 m/s. If you accidentally stub your toe in the dark, estimate the time it takes the nerve impulse to travel to your brain.

Solution # 6

9. A jet plane has a takeoff speed of $v_{to} = 75$ m/s and can move along the runway at an average acceleration of 1.3 m/s^2. If the length of the runway is 2.5 km, will the plane be able to use this runway safely? Defend your answer.

Solution # 7

11. The cheetah can reach a top speed of 114 km/h (71 mi/h). While chasing its prey in a short sprint, a cheetah starts from rest and runs 45 m in a straight line, reaching a final speed of 72 km/h. (a) Determine the cheetah's average acceleration during the short sprint, and (b) find its displacement at $t = 3.5$ s.

Solution # 8

20. V A particle starts from rest and accelerates as shown in Figure P2.20. Determine (a) the particle's speed at $t = 10.0$ s and at $t = 20.0$ s, and (b) the distance traveled in the first 20.0 s.

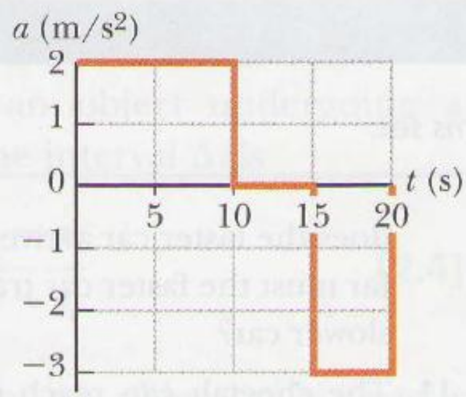


Figure P2.20

21. A 50.0-g Super Ball traveling at 25.0 m/s bounces off a brick wall and rebounds at

Solution # 9

27. T An object moving with uniform acceleration has a velocity of 12.0 cm/s in the positive x-direction when its x-coordinate is 3.00 cm. If its x-coordinate 2.00 s later is -5.00 cm, what is its acceleration?

Solution # 10

39. A car starts from rest and travels for 5.0 s with a uniform acceleration of $+1.5\ \mathrm{m/s^2}$. The driver then applies the brakes, causing a uniform acceleration of $-2.0\ \mathrm{m/s^2}$. If the brakes are applied for 3.0 s, (a) how fast is the car going at the end of the braking period, and (b) how far has the car gone?

Solution # 11

45. A ball is thrown vertically upward with a speed of 25.0 m/s. (a) How high does it rise? (b) How long does it take to reach its highest point? (c) How long does the ball take to hit the ground after it reaches its highest point? (d) What is its velocity when it returns to the level from which it started?

Solution # 12

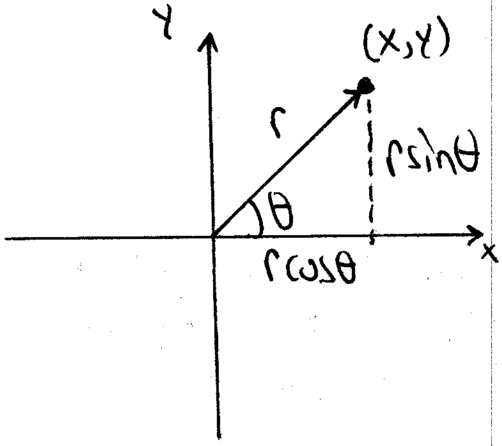
47. A certain freely falling object, released from rest, requires 1.50 s to travel the last 30.0 m before it hits the ground. (a) Find the velocity of the object when it is 30.0 m above the ground. (b) Find the total distance the object travels during the fall.

Solution # 13

71. A stuntman sitting on a tree limb wishes to drop vertically onto a horse galloping under the tree. The constant speed of the horse is 10.0 m/s, and the man is initially 3.00 m above the level of the saddle. (a) What must be the horizontal distance between the saddle and the limb when the man makes his move? (b) How long is he in the air?

Physics 210 - Problem Set # I Solutions

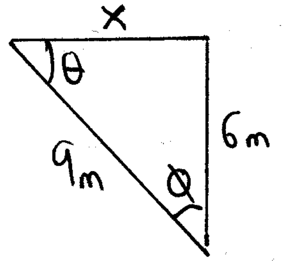
(1)



$x = r\cos\theta = (2.5\,m)(\cos 35^\circ) = 2.05\,m$

$y = r\sin\theta = (2.5\,m)\sin 35^\circ = 1.43\,m$

(2)

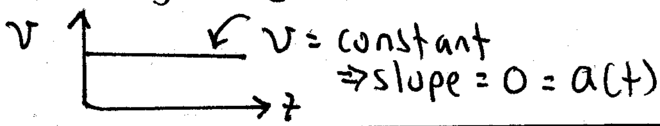


(a) $x^2 + 6^2 = 9^2 \Rightarrow x = \sqrt{9^2 - 6^2} = 6.71$

(b) $\tan\theta = \dfrac{6}{x} = \dfrac{6}{6.71} = 0.894$

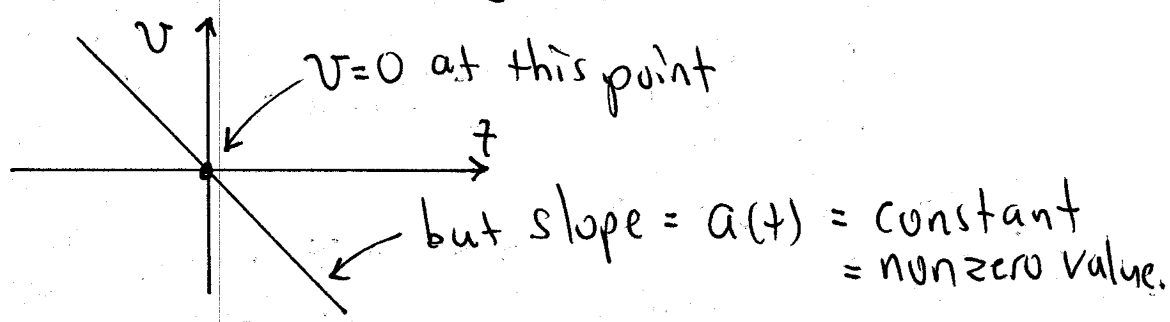
(c) $\sin\phi = \dfrac{x}{9} = \dfrac{6.71}{9} = 0.745$

(3) If $v \neq 0$, acceleration can be zero for the situation in which the object is moving at constant velocity.
Note: $a(t)$ = slope of $v(t)$ curve, and if $v(t)$ = constant, then slope $= 0 = a(t)$.

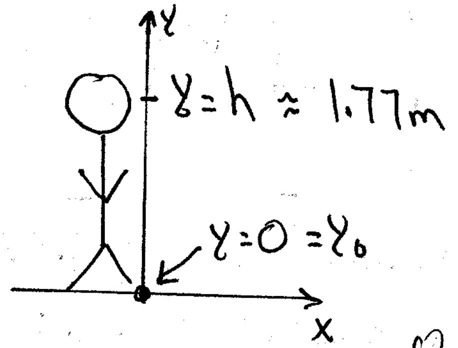


(4) If $v = 0$, acceleration can be nonzero for the case of an object thrown straight up in the air. At the top of its path where it momentarily stops, the velocity is zero, but its acceleration is $a = -g = -9.8\,m/sec^2$

Graphically:



(5)



(from a Google search, the average height of an American is 177cm)

Eq. M3: $y = \cancel{y_0}^{\,0} + v_0 t + \cancel{\tfrac{1}{2}at^2}^{\,0}$

y → final position $= h$

y_0 → initial position $= 0$

v_0 → 100m/sec

$\tfrac{1}{2}at^2$ → assume impulse travels at constant speed $\Rightarrow a = 0$

$$h = v_0 t \Rightarrow t = \frac{h}{v_0} = \frac{1.77\text{m}}{100\text{m/sec}} = 0.0177\text{ sec} \approx 0.02\text{ sec}$$

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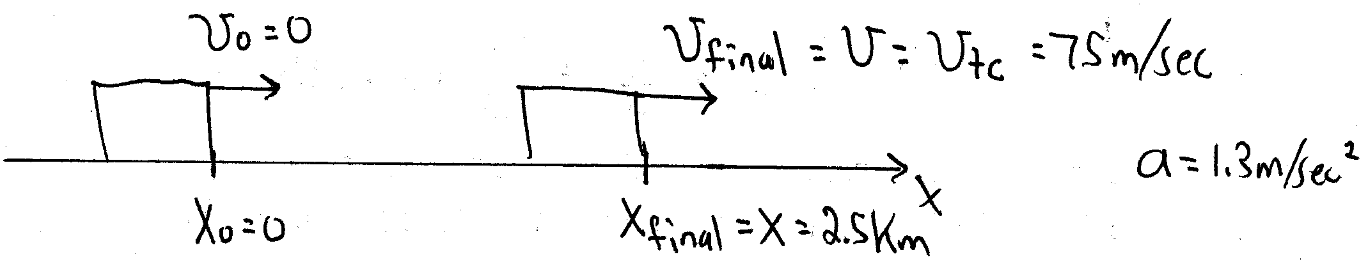
(6)



The question is: can the plane attain a speed of $v_{tc} = 75\text{m/sec}$ over a distance $x = 2.5\text{Km}$ with an acceleration of $a = 1.3\text{m/sec}^2$? Assume the plane starts from rest: $v_0 = 0$. Let's calculate what x should be using this information:

Eq. M4: $x = \cancel{x_0}^{\,0} + \dfrac{v^2 - \cancel{v_0^2}^{\,0}}{2a}$ ← $v_0 = 0$ (initial velocity), $v = 75\text{m/sec}$

x → to be found

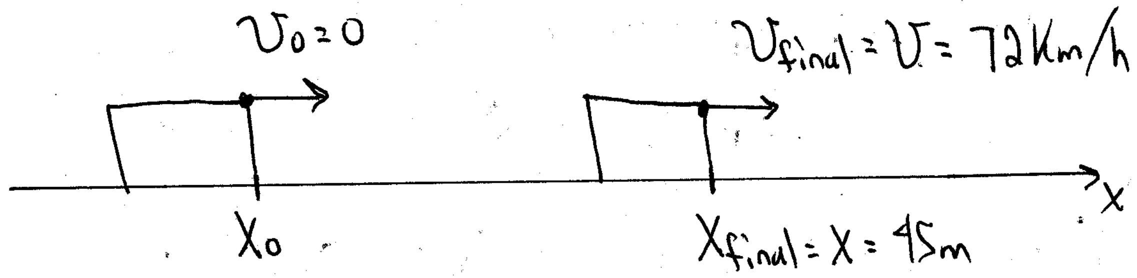
x_0 → initial $= 0$

a → 1.3m/sec^2

$$x = \frac{v^2}{2a} = \frac{(75\text{m/sec})^2}{2(1.3\text{m/sec}^2)} = 2163\text{m} \approx 2.2\text{Km} < 2.5\text{Km}$$

Since this is less than the length of the road way → the plane can safely use the runway

7



(a) $a_{ave} = \dfrac{\Delta v}{\Delta t}$ ← we need Δt ⇒ use Eq. M4 instead

$$X = \cancel{X_0}^{\,0} + \frac{v^2 - \cancel{v_0^2}^{\,0}}{2a}$$

X ↓ final position $= 45$m

X_0 ↓ initial $= 0$

v_0 = initial = 0

v = final velocity = 72 Km/hr

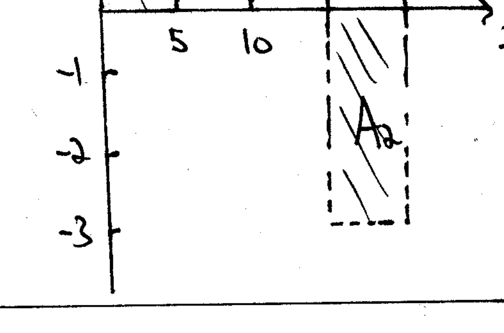
$$X = \frac{v^2}{2a} \Rightarrow a = \frac{v^2}{2X} = \frac{\left(72\frac{\cancel{Km}}{\cancel{hr}} \times \frac{1000m}{\cancel{Km}} \times \frac{1\cancel{hr}}{3600sec}\right)^2}{2(45m)}$$

$$= 4.44 m/sec^2$$

(b) Eq. M3: $X = \cancel{X_0}^{\,0} + \cancel{v_0 t}^{\,0} + \frac{1}{2}at^2$

$$X = \frac{1}{2}at^2 = \frac{1}{2}(4.44 m/sec^2)(3.5sec)^2 = 27.2m$$

8



$v_0 = 0$
particle starts from rest

(a) $\Delta v = v - \cancel{v_0}^{\,0}$ = Area under $a(t)$

$v = A_1 = (2m/sec^2)(10sec) = 20m/sec$

$\Rightarrow v(t = 10sec) = 20 m/sec$

$v(t = 20sec)$ = Area of the two rectangles

$$v(t = 20sec) = \underbrace{(2m/sec^2)(10sec)}_{A_1} - \underbrace{(3m/sec^2)(5sec)}_{A_2}$$

$= 5m/sec$

(b) From 0 to 10sec: $X_1 = \cancel{X_0}^{\,0} + \cancel{V_0 t}^{\,0} + \frac{1}{2}at^2$

$$X_1 = \frac{1}{2}(2\,m/sec^2)(10\,sec)^2 = 100\,m$$

From 10sec to 15sec: $X_2 = \underbrace{X_1}_{\substack{100m \\ =\text{initial} \\ \text{position}}} + \underbrace{V_{01}}_{20m/sec}\, t + \cancel{\frac{1}{2}at^2}^{\,0}$

$t = \Delta t = 15 - 10 = 5\,sec$

$$X_2 = X_1 + V_{01}t = 100m + \left(20\frac{m}{sec}\right)(5sec)$$

$$= 200m$$

From 15sec to 20sec: $X_3 = \underbrace{X_2}_{\substack{\text{initial} \\ =200m}} + \underbrace{V_{02}}_{\substack{\text{initial} \\ =20m/sec}}\, t + \frac{1}{2}\underbrace{a}_{-3m/sec^2} t^2$ $\quad (t = \Delta t = 5sec)$

$$= 200m + \left(20\frac{m}{sec}\right)(5sec) + \frac{1}{2}\left(-3\frac{m}{sec^2}\right)(5sec)^2$$

$\boxed{X_3 = 262.5m}$ total distance traveled in 1^{st} 20sec

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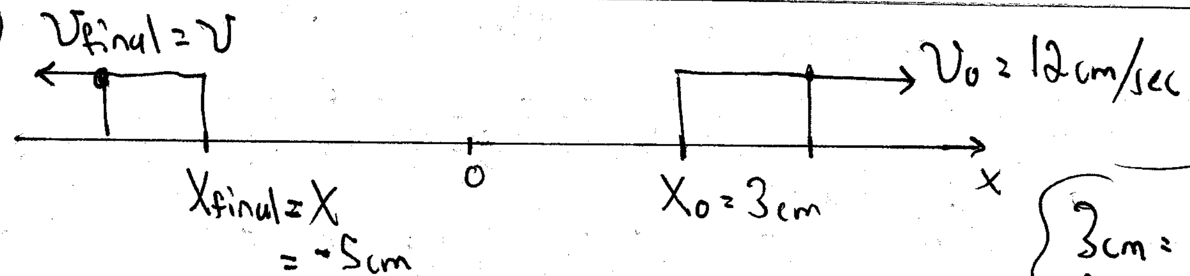
(9)



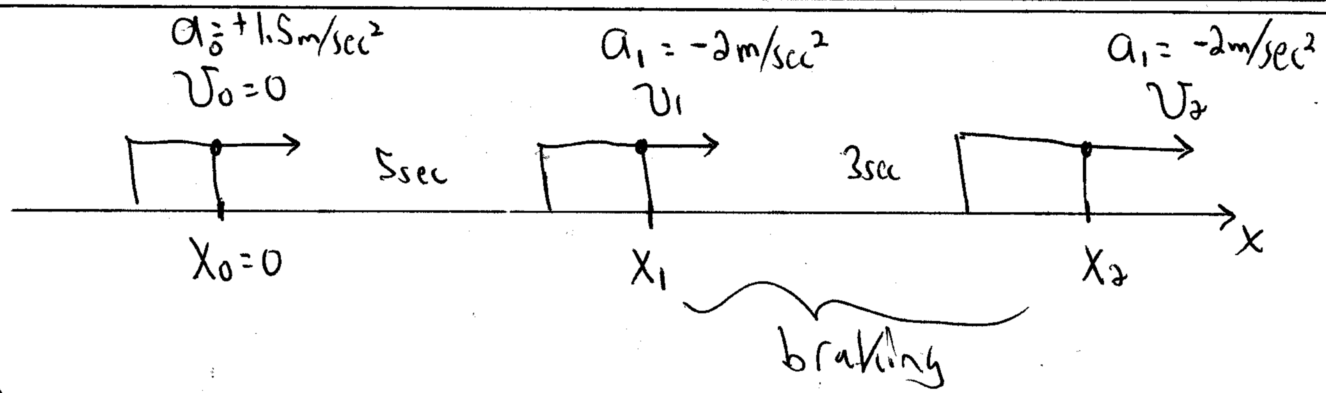
3cm = 0.03m
5cm = 0.05m

Eq. M3: $X = \underbrace{X}_{\substack{\text{final} \\ =-5cm}} = \underbrace{X_0}_{\substack{\text{initial} \\ =3cm}} + \underbrace{V_0}_{\substack{\text{initial} \\ =12cm/sec}}\, t + \frac{1}{2}at^2$ $\quad t = 2sec$

$$\Rightarrow \frac{1}{2}at^2 = X - X_0 - V_0 t \Rightarrow a = \frac{2(X - X_0 - V_0 t)}{t^2}$$

$$a = \frac{2\left(-0.05\text{m} - 0.03\text{m} - [0.12\text{m/sec}][2\text{sec}]\right)}{(2\text{sec})^2} = -0.16\text{m/sec}^2$$

(10)



(a)

From $X = X_0$ to $X = X_1$: $a_0 = 1.5\text{m/sec}^2 \Rightarrow$ determine v_1

Eq. M2: $\underbrace{v_1}_{\text{final}} = \underbrace{\cancel{v_0}^{\,0}}_{\substack{\text{initial}\\=0}} + \underbrace{a_0}_{1.5\text{m/sec}^2}\,t \leftarrow 5\text{sec}$

$$v_1 = at = (1.5\text{m/sec}^2)(5\text{sec}) = 7.5\text{m/sec}$$

From $x = X_1$ to $X = X_2$: $a_1 = -2\text{m/sec}^2 \Rightarrow$ determine v_2

Eq. M2: $v_2 = \underbrace{v_1}_{\substack{\text{initial}\\=7.5\text{m/sec}}} + \underbrace{a_1}_{-2\text{m/sec}^2}\,t \leftarrow 3\text{sec}$

$$v_2 = (7.5\text{m/sec}) + (-2\text{m/sec}^2)(3\text{sec}) = 1.5\text{m/sec}$$

(b) From $X = X_0$ to $X = X_1$: $\underbrace{X_1}_{\text{final}} = \underbrace{\cancel{X_0}^{\,0}}_{\substack{\text{initial}\\=0}} + \underbrace{\cancel{v_0}^{\,0}}_{\substack{\text{initial}\\=0}}t + \frac{1}{2}\underbrace{a_0}_{1.5\frac{\text{m}}{\text{sec}^2}}t^2 \leftarrow 5\text{sec}$

$$X_1 = \frac{1}{2}at^2 = \frac{1}{2}(1.5\,m/sec^2)(5\,sec)^2 = 18.75\,m$$

From $x = X_1$ to $X = X_2$:
$$\underbrace{X_2}_{\text{final}} = \underbrace{X_1}_{\substack{\text{initial}\\ = 18.75m}} + \underbrace{v_1}_{\substack{\text{initial}\\ = 7.5m/sec}} t + \frac{1}{2}\underbrace{a_1}_{-2m/sec^2} \overbrace{t^2}^{3\,sec}$$

$$X_2 = (18.75\,m) + (7.5\,m/sec)(3\,sec) + \frac{1}{2}(-2\,m/sec^2)(3\,sec)^2$$
$$= 32.25\,m$$

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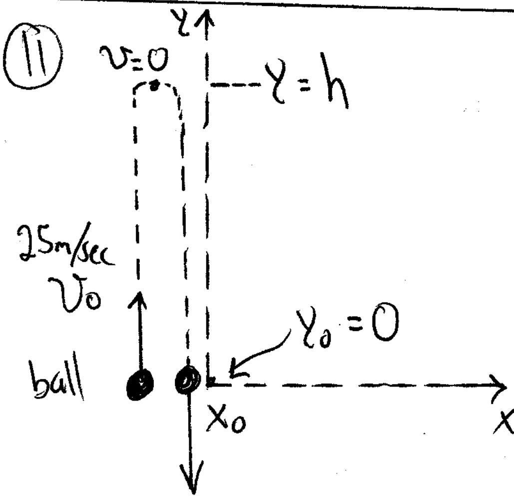
(11)



$v = 0$ at top of path

$v_0 = 25\,m/sec$

$y_0 = 0$ = initial position

$a = -g = -9.8\,m/sec^2$

(a) To find height h, use Eq. M4:

$$\text{Eq. M4:}\quad \underbrace{y}_{\substack{\text{final}\\ \text{position}\\ = h}} = \underbrace{\cancel{y_0}^{\,0}}_{\substack{\text{initial}\\ \text{position}\\ = 0}} + \frac{\cancel{v^2}^{\,0} - v_0^2}{2(-g)}$$

v = final velocity $= 0$ at top
v_0 = initial $= 25\,m/sec$

$$h = \frac{-v_0^2}{2(-g)} = \frac{v_0^2}{2g} = \frac{(25\,m/sec)^2}{2(9.8\,m/sec^2)} = 31.89\,m$$

(b) Eq. M2:
$$\underbrace{\cancel{v}^{\,0}}_{\substack{\text{final}\\ = 0}} = \underbrace{v_0}_{\substack{\text{initial}\\ = 25m/sec}} - gt \quad \Rightarrow \quad 0 = v_0 - gt$$

$$gt = v_0$$

$$t = \frac{v_0}{g} = \frac{25\,m/sec}{9.8\,m/sec^2} = 2.55\,sec$$

(c) Eq. M3: $\cancel{y}^{0} = \cancel{y_0}^{0} + v_0 t - \frac{1}{2} g t^2$

y: final position = 0 (the ground); y_0: initial position = 0 (the ground); v_0: initial = 25 m/sec

$$0 = v_0 t - \frac{1}{2} g t^2 = t\left(v_0 - \frac{1}{2} g t\right)$$

$(t = 0)$ or $\left(v_0 - \frac{1}{2} g t = 0\right)$

$t = 0$ → not interesting solution ⇒ of course $y = 0$ at $t = 0$

$\frac{1}{2} g t = v_0$

$t = \frac{2 v_0}{g}$

$$t = \frac{2 v_0}{g} = \frac{2(25\,\text{m/sec})}{9.8\,\text{m/sec}^2} = 5.10\,\text{sec} = \text{total time to go up and back down}$$

we could have guessed this from Part (b): the time it takes to go up = time it takes to come down by symmetry $= 2(2.55\,\text{sec}) = 5.10\,\text{sec}$

Time it takes to come down: $5.10\,\text{sec} - 2.55\,\text{sec} = 2.55\,\text{sec}$

(d) Eq. M2: $v = v_0 - g t$

v: final velocity; v_0: initial = 25 m/sec; t: 5.10 sec

$$v = 25\,m/sec - (9.8\,m/sec^2)(5.10\,sec) = -25\,m/sec$$

minus sign means velocity is pointed downward (it is in the negative y-direction)

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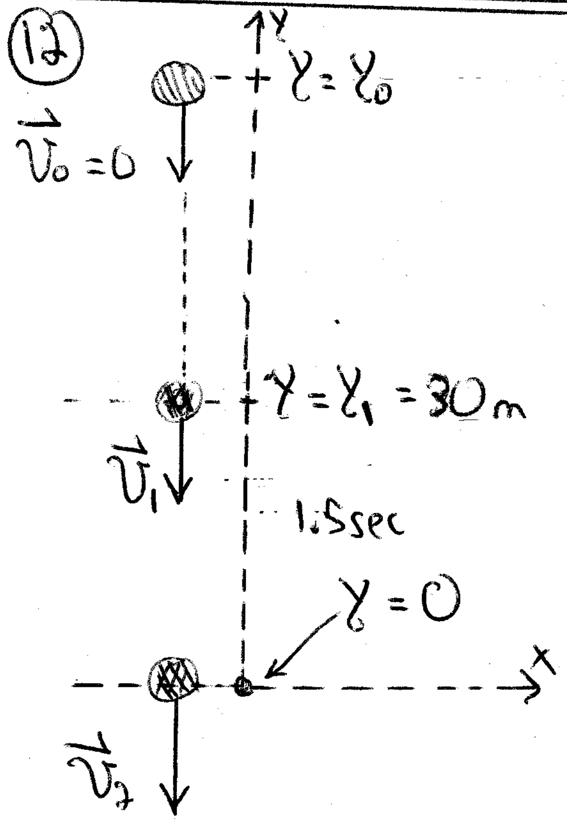
(12)



(a) Ball is dropped at $y = y_0$ and eventually reaches $y = y_1 = 30m$ above the ground. Problem is asking for v_1 at $y = y_1$

Use Eq. M3:

$$\underbrace{\cancel{y}^{\,0}}_{\substack{\text{final}\\\text{position}\\=0}} = \underbrace{y_0}_{\substack{\text{initial}\\=y_1\\=30m}} + \underbrace{v_0}_{\substack{\text{initial}\\=v_1}} t - \frac{1}{2} g \underbrace{t}_{t=1.5sec}^2$$

$$0 = y_1 + v_1 t - \frac{1}{2} g t^2 \Rightarrow v_1 t = \frac{1}{2} g t^2 - y_1$$

$$v_1 = \frac{\frac{1}{2} g t^2 - y_1}{t}$$

$$v_1 = \frac{\frac{1}{2}(9.8\,m/sec^2)(1.5sec)^2 - 30m}{1.5sec} = -12.65\,m/sec$$

minus sign $\Rightarrow \vec{v}_1$ is in the negative y-direction

(b) To go from $y = y_0$ to $y = y_1 = 30m$, use Eq. M4

Eq. M4: $\underset{\substack{\downarrow \\ \text{final} \\ = 30m = y_1}}{y} = \underset{\substack{\downarrow \\ \text{initial}}}{y_0} + \dfrac{v^2 - \cancel{v_0^2}^{\,0}}{2(-g)}$ ← v = final = $v_1 = -12.65$ m/sec

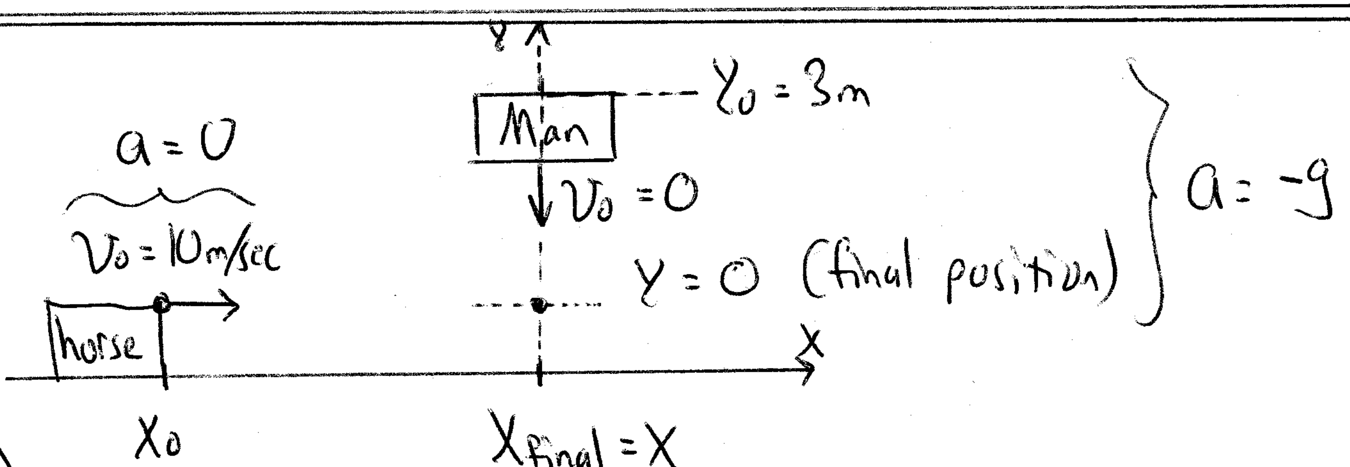
v_0 = initial = 0

$$y_1 = y_0 + \frac{v^2}{2(-g)} = y_0 - \frac{v^2}{2g}$$

$$\Rightarrow y_0 = y_1 + \frac{v^2}{2g} = 30m + \frac{(-12.65m/sec)^2}{2(9.8m/sec^2)}$$

$$= 38.16m$$

13



(a)

Horizontal distance $= (x - x_0)$

$\underbrace{\text{Time it takes for man to fall 3m}}$ = $\underbrace{\text{time it takes for horse to move distance } (x - x_0)}$

Use Eq. M3: $\underset{\substack{\downarrow \\ \text{final} \\ =0}}{\cancel{y}^{\,0}} = \underset{\substack{\downarrow \\ \text{initial} \\ =3m}}{y_0} + \underset{\substack{\downarrow \\ \text{initial} \\ =0}}{\cancel{v_0}^{\,0}}t - \frac{1}{2}gt^2$

$$0 = y_0 - \frac{1}{2}gt^2$$

Use Eq. M3: $x = x_0 + \underset{\substack{\downarrow \\ 10m/sec}}{v_0}t - \cancel{\frac{1}{2}\underset{\substack{\downarrow \\ a=0}}{a}t^2}^{\,0}$

For Man: $0 = y_0 - \frac{1}{2} g t^2$

$$\frac{1}{2} g t^2 = y_0$$

$$t = \sqrt{\frac{2y_0}{g}}$$

For Horse: $(x - x_0) = v_0 t$ (horse moves at constant speed $\Rightarrow a = 0$)

$$t = \frac{x - x_0}{v_0}$$

$$t_{Man} = t_{Horse} \Rightarrow \sqrt{\frac{2y_0}{g}} = \frac{x - x_0}{v_0}$$

$$\Rightarrow (x - x_0) = v_0 \sqrt{\frac{2y_0}{g}} = \left(10 \frac{m}{sec}\right) \sqrt{\frac{2(3m)}{9.8 m/sec^2}}$$

$$= 7.82 m$$

(b) $t = \sqrt{\frac{2y_0}{g}} = \frac{x - x_0}{v_0} = \frac{7.82m}{10 m/sec} = 0.782 sec$