Phys 111 HW3
Solutions

#1) 1223727 — solution provided in problem print out

#2) $\vec{a} = 1\hat{j}$ $\quad \vec{V}_0 = 9\hat{i}$ $\quad \vec{r}_0 = 0$ ← at origin

Solve for motion in x, y position separately

$$x = \cancel{x_0}^{0} + \underbrace{V_{0x}}_{9} t + \cancel{\tfrac{1}{2} a_x t^2}^{0} \Rightarrow x(t) = 9t$$

$$y = \cancel{y_0}^{0} + \cancel{V_{0y} t}^{0} + \tfrac{1}{2} \underbrace{a_y}_{1} t^2 \Rightarrow y(t) = \frac{t^2}{2}$$

$\vec{r} = x(t)\hat{i} + y(t)\hat{j}$

a) $$\boxed{\vec{r} = 9t\hat{i} + \frac{t^2}{2}\hat{j}}$$

b) $\vec{V} = \dfrac{d\vec{r}}{dt} = 9\hat{i} + t\hat{j}$

c) $\vec{r}(t=9) = 81\hat{i} + \dfrac{81}{2}\hat{j}$

$$\boxed{x = 81 \qquad y = 40.5}$$

d) $\vec{V}(t=9) = 9\hat{i} + 9\hat{j}$ $\quad |\vec{V}| = \sqrt{9^2 + 9^2}$
$= 12.7$

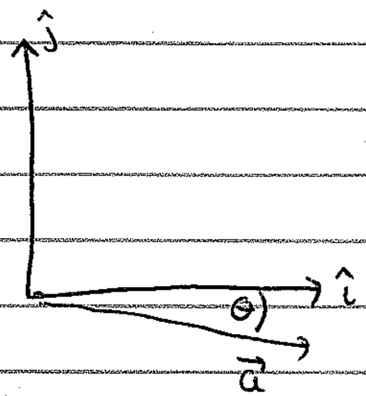
#3) 1742818

a) $$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$= \frac{19\hat{i} - \hat{j} - (4\hat{i} + \hat{j})}{17} = \frac{15}{17}\hat{i} - \frac{2}{17}\hat{j}$$

$$\vec{a} = 0.882\hat{i} - 0.118\hat{j}$$

b)



$$\tan\theta = \frac{|-0.118|}{0.882}$$

$\theta = 7.62^\circ$ ← note: answer not accurate enough use

$$\tan\theta = \frac{2/\cancel{17}}{15/\cancel{17}} = \frac{2}{15} = \cancel{7.59}$$

$\boxed{\text{so } \theta = 7.59^\circ}$

report ~~7.59~~° $\theta = -7.59^\circ$

counter clockwise from +x axis.

c) $$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

$\vec{a} = \frac{15}{17}\hat{i} - \frac{2}{17}\hat{j}$

$4\hat{i} + 1\hat{j}$

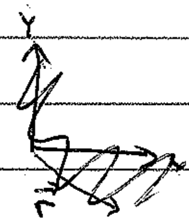
$16\hat{i} - 1.6\hat{j}$

$$\vec{r}(t) = 16\hat{i} - 1.6\hat{j} + (4\hat{i} + 1\hat{j})t + \frac{1}{2}\left(\frac{15}{17}\hat{i} - \frac{2}{17}\hat{j}\right)t^2$$

$$\vec{r}(t=30) = \hat{i}\left(16 + 120 + \frac{1}{2}\frac{15}{17}(30)^2\right) + \hat{j}\left(-1.6 + 30 - \frac{1}{2}\left(\frac{2}{17}\right)30^2\right)$$

$$= 533\hat{i} + -24.5\hat{j}$$

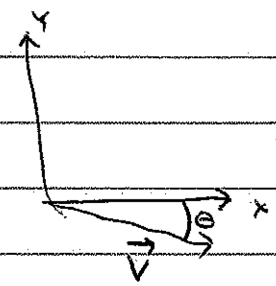
d)



Direction of motion determined by velocity.

$$\vec{v}(t) = \frac{d\,r(t)}{dt} = (4\hat{i} + 1\hat{j}) + \left(\frac{15}{17}\hat{i} - \frac{2}{17}\hat{j}\right)t$$

$$v(t=30) = \left(4 + \frac{15}{17}\cdot 30\right)\hat{i} + \left(1 - \frac{2}{17}\cdot 30\right)\hat{j}$$

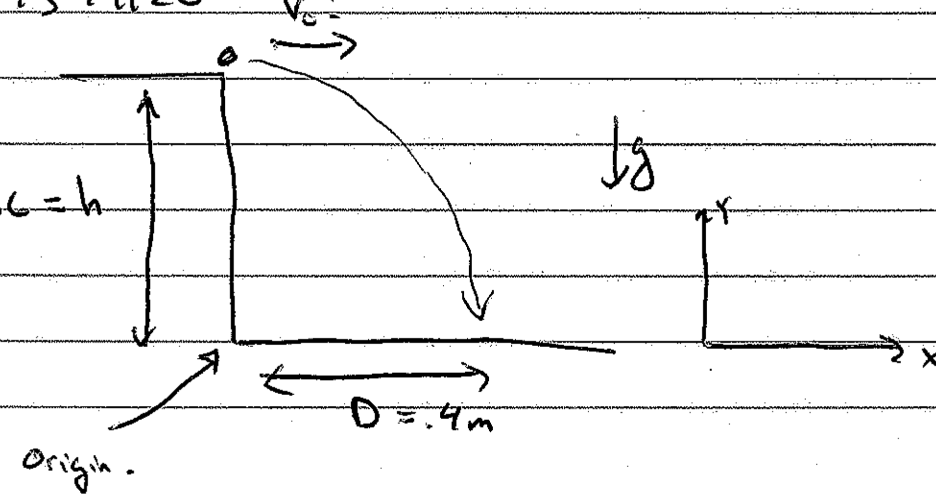


$$|\theta| = \arctan\left(\frac{1 - \frac{2}{17}\cdot 30}{4 + \frac{15}{17}\cdot 30}\right)$$

$$\theta = 4.75^\circ$$

$\Rightarrow \theta = -4.75^\circ$ relative to counter-clockwise.

#4) 1379120



time

x motion $X = V_{0x} t$

Y motion ~~Y~~

$$Y(t) = h - \frac{1}{2} g t^2$$

when mug hits floor $Y(t) = 0$

$$\Rightarrow \quad t = \sqrt{\frac{2h}{g}} \quad \text{time that mug hits floor}$$

$$V_0 = \frac{X}{t} \Rightarrow \text{when hits floor } V_0 = \frac{D}{t}$$

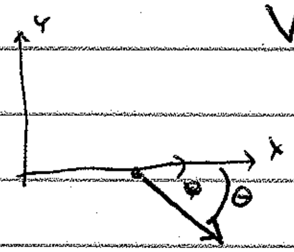
$$V_0 = \frac{D}{\sqrt{2h/g}} = \frac{.4}{\sqrt{2(1.36)/9.8}}$$

a) $V_0 = 0.759$ m/s

b) calculate $\vec{V}$ when mug hits floor.

$$V_x = V_0 = \cancel{0.779}$$

$$V_y(t) = \cancel{V_{0y}}^{\,0} - gt$$



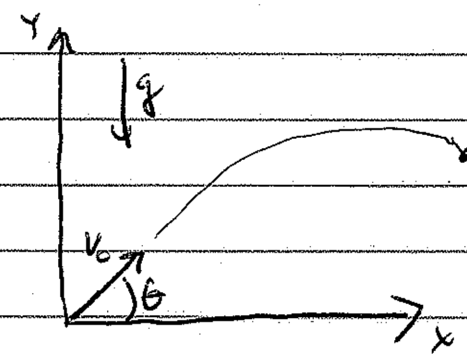
$$\tan\theta = \frac{|V_y|}{V_x}$$

$$\tan\theta = \frac{gt}{V_0} = \frac{g\left(\sqrt{\frac{2h}{g}}\right)}{\frac{D}{\sqrt{2h/g}}} = \frac{\cancel{g}\left(\frac{2h}{\cancel{g}}\right)}{D}$$

$$\tan\theta = \frac{2h}{D} = \frac{2(1.36)}{(0.4)}$$

$$\boxed{\theta = 81.6^\circ}$$

#5 1333649



$$x = \cancel{x_0}^{0} + V_{0x}t + \frac{1}{2}\cancel{a_x}^{0}t^2$$

$$\boxed{x = V_{0x}t = V_0\cos\theta\, t}$$

$$Y = \cancel{Y_0}^{0} + V_{0y}t - \frac{1}{2}gt^2$$

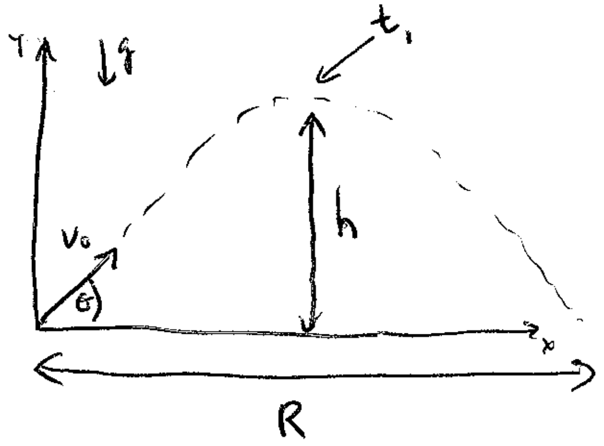
$$Y = (V_0\sin\theta)t - \frac{1}{2}gt^2$$

$$x(t=36) = 340(\cos 58^\circ)36 = 6486 \text{ m}$$

$$Y(t=36) = 340 \sin 58° \cdot 36 - \frac{1}{2}(9.8)(36)^2$$

$$= 4030 \text{ m}$$

#6| 1233306



given $h = R$

$$X - X_0 \equiv R = V_{0x} t_g$$ ← time rock hits ground

$$Y - Y_0 \equiv h = V_{0y} t_1 - \frac{1}{2} g t_1^2$$

t_1 time for rock to reach maximum height.

what is t_1? $$V_y(t) = V_{0y} - gt$$

zero at max hieght

$$t_1 = \frac{V_{0y}}{g}$$

What is time for rock to hit ground?

$$Y - Y_0 = 0 = V_{0y} t_g - \frac{1}{2} g t_g^2 = t_g \left(V_{0y} - \frac{1}{2} g t_g \right)$$

$t_g = 0$ (unphysical solution)

or $\boxed{t_g = \frac{2V_{0y}}{g}}$ ← note twice the time it takes to reach peak as one would expect.

$$R = V_{ox} t_g = V_o \cos\theta \left(\frac{2V_{oy}}{g}\right)$$

$$h = V_{oy}\frac{V_{oy}}{g} - \frac{1}{2}g\left(\frac{V_{oy}}{g}\right)^2 = \frac{1}{2}\frac{V_{oy}^2}{g} = \frac{1}{2}\frac{V_o \sin\theta}{g} V_{oy}$$

$$R = h \quad \Rightarrow \quad \cancel{V_o}\cos\theta\left(2\frac{\cancel{V_{oy}}}{\cancel{g}}\right) = \frac{1}{2}\frac{\cancel{V_o}\sin\theta}{\cancel{g}}\cancel{V_{oy}}$$

a)

$$\frac{\sin\theta}{\cos\theta} = \tan\theta = 4$$

$$\Rightarrow \theta = 76.0^\circ$$

b) at optimal angle of 45° (note $R \neq h$ any more)

$$\cancel{t_g = \frac{2V_{oy}}{g}} \quad R = V_o \cos\theta\left(\frac{2V_{oy}}{g}\right)$$

$$R = \frac{V_o^2\, 2\sin\theta\cos\theta}{g} = \frac{V_o^2}{g} \quad \text{for } \theta = 45^\circ$$

Need ~~initial value of V_o~~ In terms of original Range

$$\Rightarrow \cancel{R = V_o \frac{2V_{oy}}{g}\cos\theta} \quad R_o \equiv V_o^2 \frac{2\sin\theta\cos\theta}{g} \leftarrow 76^\circ$$

$$h = \cancel{\frac{1}{2}\frac{V_{oy}^2}{2}}$$

$$\frac{R}{R_o} = \frac{\sin 45^\circ \cos 45^\circ}{\sin 76^\circ \cos 76^\circ}$$

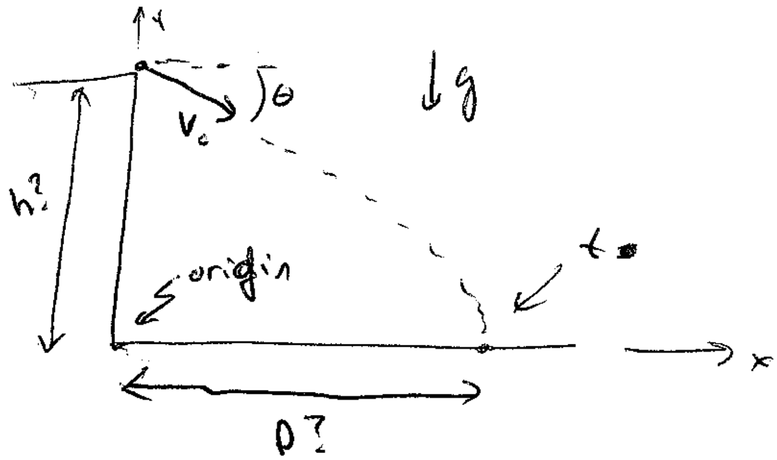
$$\frac{R}{R_o} = 2.13$$

c) note on previous page when we enforce $R = h$

that g ~~code~~ cancels $\longrightarrow$ ~~a~~ solution independent

of g $\Rightarrow$ same on ~~day~~ any planet.

#7 1333655



a) $D = x - x_0 = V_{0x} t$

$D = V_0 \cos\theta\, t = 7.5 \cdot \cos 17° \cdot 5$

$D = 35.9$

b) $-h = y - y_0 = V_{0y} t - \frac{1}{2} g t^2$

zero h

$h = \frac{1}{2} g t^2 - V_{0y} t = \frac{1}{2} 9.8 (5)^2 - (-7.5) \sin 17° \cdot 5$

$V_{0y} < 0$

$h = 133$ m

c) $-h = V_{0y} t - \frac{1}{2} g t^2$

10 $0 = -\frac{1}{2} g t^2 + V_{0y} t + h$

$$t = \frac{-V_{0y} \pm \sqrt{V_{0y}^2 + 4 \frac{1}{2} g h}}{-g}$$

$$V_{0y} = -V_0 \sin\theta$$

$$t = -\frac{V_0 \sin\theta}{g} \mp \frac{\sqrt{V_0^2 \sin^2\theta + 2gh}}{g}$$

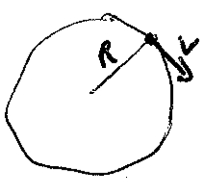
choose + root so $t > 0$

$$t = -\frac{V_0 \sin\theta}{g} + \frac{\sqrt{V_0^2 \sin^2\theta + 2gh}}{g}$$

$$= \frac{-7.5 \sin 17}{9.8} + \frac{\sqrt{(7.5)^2 \sin^2 17^\circ + 2(9.8)10}}{9.8}$$

$$t = 1.22 \text{ sec}$$

#8 1233328



$$T = \frac{2\pi R}{V}$$

$$\frac{1}{T} = \frac{V}{2\pi R}$$

revolutions/sec

$$V = \left(\frac{1}{T}\right) 2\pi R$$

a) $V_1 = (7.25)\, 2\pi (0.6)$

$= 8.7\pi$ m/s

$V_2 = 6.43 \cdot 2\pi \cdot (.9)$ $\Leftarrow$ 6.43 rev/s gives faster speed.

$V_2 = 11.6\pi$ m/s

b) $a_c = \frac{V^2}{R} = \frac{(8.7\pi)^2}{0.6} = 1245$ m/s^2

c) $a_c = \frac{(11.6\pi)^2}{.9} = 1476$ m/s^2

#9) 1233287

$$a = \frac{V^2}{R} \Rightarrow \frac{1}{T} = \frac{V}{2\pi R}$$

$$\frac{1}{T} = \frac{\sqrt{aR}}{2\pi R} = \frac{1}{2\pi}\sqrt{\frac{a}{R}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{16.6 \cdot 9.8}{29 \cdot 12\frac{in}{ft} \cdot 2.54\frac{cm}{in} \cdot \frac{1m}{100cm}}}$$

$$\frac{1}{T} = 0.683 \text{ revolutions/sec.}$$

HW3 (3199696)

Due: Tue Feb 12 2013 10:00 AM EST

Question 1 2 3 4 5 6 7 8 9

1. Question Details SerPSE8 4.P.001.soln. [1223727]

A motorist drives south at 28.0 m/s for 3.00 min, then turns west and travels at 25.0 m/s for 2.60 min, and finally travels northwest at 30.0 m/s for 1.00 min. For this 6.60 min trip, find the following values.

(a) total vector displacement
6400 m (magnitude) 36.1 ° south of west
(b) average speed
27.1 m/s
(c) average velocity
16.2 m/s (magnitude) 36.1 ° south of west

Solution or Explanation

Note the values in this solution reflect those of the text book question, not the values you may have received for this question above.

P4.1

$x(m)$	$y(m)$
0	−3 600
−3 000	0
−1 270	1 270
−4 270 m	−2 330 m

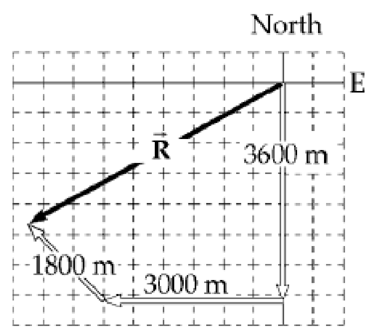


FIG. P4.1

(a) Net displacement $= \sqrt{x^2+y^2}$ at $\tan^{-1}(y/x)$

$$\vec{R} = \boxed{4.87 \text{ km at } 28.6° \text{ S of W}}$$

(b) $$\text{Average speed} = \frac{(20.0\ \text{m/s})(180\ \text{s})+(25.0\ \text{m/s})(120\ \text{s})+(30.0\ \text{m/s})(60.0\ \text{s})}{180\ \text{s}+120\ \text{s}+60.0\ \text{s}} = \boxed{23.3\ \text{m/}}$$

(c) $$\text{Average velocity} = \frac{4.87\times10^3\ \text{m}}{360\ \text{s}} = \boxed{13.5\ \text{m/s along } \vec{R}}$$

Need Help? Read It

2. Question Details SerPSE8 4.P.006.WI. [1333648]

A particle initially located at the origin has an acceleration of $\vec{a} = 1.00\hat{j}$ m/s^2 and an initial velocity of $\vec{v}_i = 9.00\hat{i}$ m/s.

(a) Find the vector position of the particle at any time t (where t is measured in seconds).

(9 $t\,\hat{i}$ + 0.5 $t^2\,\hat{j}$) m

(b) Find the velocity of the particle at any time t.

([ ] 9 $\hat{\mathbf{i}}$ + [ ] 1 $t\,\hat{\mathbf{j}}$) m/s

(c) Find the coordinates of the particle at t = 9.00 s.

x = [ ] 81 m

y = [ ] 40.5 m

(d) Find the speed of the particle at t = 9.00 s.

[ ] 12.7 m/s

Need Help? Read It Watch It

3. Question Details SerPSE8 4.P.007.MI. [1742818]

A fish swimming in a horizontal plane has velocity $\vec{\mathbf{v}}_i$ = (4.00 $\hat{\mathbf{i}}$ + 1.00 $\hat{\mathbf{j}}$) m/s at a point in the ocean where the position relative to a certain rock is $\vec{\mathbf{r}}_i$ = (16.0 $\hat{\mathbf{i}}$ − 1.60 $\hat{\mathbf{j}}$) m. After the fish swims with constant acceleration for 17.0 s, its velocity is $\vec{\mathbf{v}}$ = (19.0 $\hat{\mathbf{i}}$ − 1.00 $\hat{\mathbf{j}}$) m/s.

(a) What are the components of the acceleration of the fish?

a_x = [ ] 0.882 m/s^2

a_y = [ ] -0.118 m/s^2

(b) What is the direction of its acceleration with respect to unit vector $\hat{\mathbf{i}}$?

[ ] -7.59 ° counterclockwise from the +x-axis

(c) If the fish maintains constant acceleration, where is it at t = 30.0 s?

x = [ ] 533 m

y = [ ] -24.5 m

In what direction is it moving?

[ ] -4.75 ° counterclockwise from the +x-axis

Need Help? Read It Master It

4. Question Details SerPSE8 4.P.009.MI. [1379120]

In a local bar, a customer slides an empty beer mug down the counter for a refill. The height of the counter is 1.36 m. The mug slides off the counter and strikes the floor 0.40 m from the base of the counter.

(a) With what velocity did the mug leave the counter?

[ ] 0.759 m/s

(b) What was the direction of the mug's velocity just before it hit the floor?

[ ] 81.6 ° (below the horizontal)

Need Help? Read It Master It

5. Question Details SerPSE8 4.P.012.WI. [1333649]

To start an avalanche on a mountain slope, an artillery shell is fired with an initial velocity of 340 m/s at 58.0° above the horizontal. It explodes on the mountainside 36.0 s after firing. What are the x and y coordinates of the shell where it explodes, relative to its firing point?

x = [ ] 6490 m

y = [ ] 4030 m

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6. Question Details SerPSE8 4.P.014. [1233306]

A rock is thrown upward from the level ground in such a way that the maximum height of its flight is equal to its horizonta range R.

(a) At what angle θ is the rock thrown?

[ ] 76 °

(b) In terms of its original range R, what is the range R_{max} the rock can attain if it is launched at the same speed but at the optimal angle for maximum range?

R_{max} = [ ] 2.13 R

(c) Would your answer to part (a) be different if the rock is thrown with the same speed on a different planet?

- Yes
- No

Explain.

Key: Since g divides out, the answer is the same on every planet.

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7. Question Details SerPSE8 4.P.016.WI. [1333655]

A ball is tossed from an upper-story window of a building. The ball is given an initial velocity of 7.50 m/s at an angle of 17.0° below the horizontal. It strikes the ground 5.00 s later.

(a) How far horizontally from the base of the building does the ball strike the ground?

[ ] 35.9 m

(b) Find the height from which the ball was thrown.

[ ] 133 m

(c) How long does it take the ball to reach a point 10.0 m below the level of launching?

[ ] 1.22 s

Need Help? Read It Watch It

8. Question Details SerPSE8 4.P.030. [1233328]

An athlete swings a ball, connected to the end of a chain, in a horizontal circle. The athlete is able to rotate the ball at the rate of 7.25 rev/s when the length of the chain is 0.600 m. When he increases the length to 0.900 m, he is able to rotate the ball only 6.43 rev/s.

(a) Which rate of rotation gives the greater speed for the ball?

- 6.43
- 7.25

(b) What is the centripetal acceleration of the ball at 7.25 rev/s?

1250 m/s^2

(c) What is the centripetal acceleration at 6.43 rev/s?

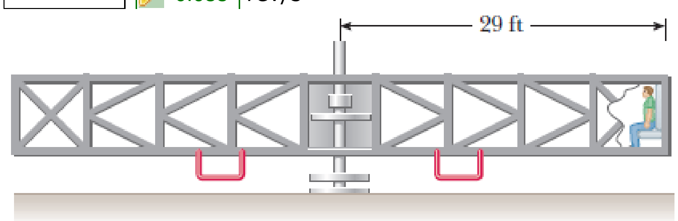
1470 m/s^2

Need Help? Read It

9. Question Details SerPSE8 4.P.029. [1233287]

The 20-*g* centrifuge at NASA's Ames Research Center in Mountain View, California, is a horizontal, cylindrical tube 58 ft long and is represented in the figure below. Assume an astronaut in training sits in a seat at one end, facing the axis of rotation 29.0 ft away. Determine the rotation rate, in revolutions per second, required to give the astronaut a centripetal acceleration of 16.6*g*.

0.683 rev/s



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Assignment Details