Please upload your solution to Problem 3 to canvas for marking after the workshop.

Problem 1

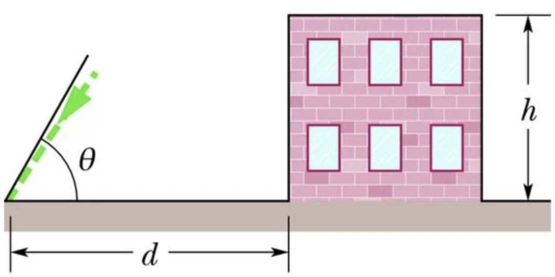
A small ball rolls horizontally off the edge of a tabletop that is 1.20 m high. It strikes the floor at a point 1.52 m horizontally from the table edge.
(a) How long is the ball in the air?
(b) What is its speed at the instant it leaves the table?

Problem 2

When a large star becomes a supernova, its core may be compressed so tightly that it becomes a neutron star, with a radius of about 20 km (about the size of the San Francisco area). If a neutron star rotates once every second:
(a) What is the speed of a particle on the star's equator?
(b) What is the magnitude of the particle's centripetal acceleration?
(c) If the neutron star rotates faster, do the answers to (a) and (b) increase, decrease, or remain the same?

Problem 3

In the figure below, 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 $\theta = 60.0°$ with the horizontal.
(a) Find h.
(b) What is the magnitude of the velocity with which the ball is thrown?
(c) What is the angle (relative to horizontal) of the velocity with which the ball is thrown?
(d) Is the angle above or below the horizontal?



Want more practice?

Further problems on projectiles: Chapter 4.4 problems 21-55
Further problems on UCM: Chapter 4.5 problems 56-68

Problem 1

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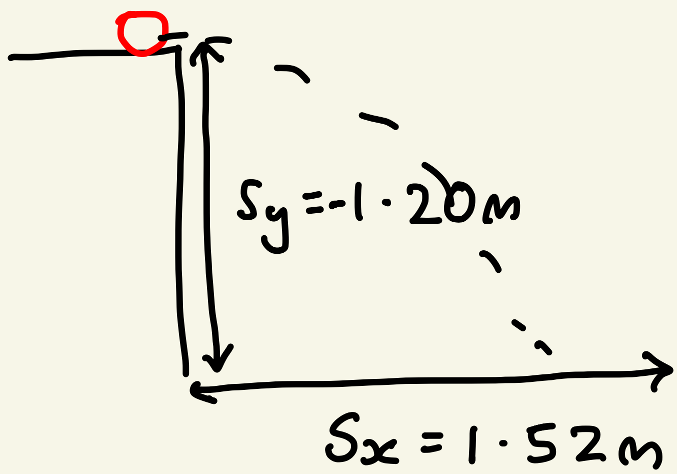
GIVEN:



KNOWN

$a_x = 0$

$a_y = -9.81\ ms^{-2}$

$U_y = 0 \therefore U = U_x$

Horizontal:

$S_x = 1.52M$

$U_x = U = ?$

$V_x =$

$a_x = 0$

Vertical:

$S_y = -1.20m$

$U_y = 0$

$V_y =$

$a_y = -9.81\ ms^{-2}$

$t = ?$

$$S_y = \cancel{U_y}^{=0} t + \frac{1}{2} a_y t^2 \therefore -4.91 t^2 = -1.20\,m$$

$$\boxed{t = \sqrt{\frac{1.20}{4.91}} = 0.494\,s}$$

$$S_x = U_x t \therefore U_x = \frac{1.52m}{0.494s} = \boxed{3.08\ ms^{-1} = U}$$

Problem 2

When a large star becomes a supernova, its core may be compressed so tightly that it becomes a neutron star, with a radius of about 20 km (about the size of the San Francisco area). If a neutron star rotates once every second:
(a) What is the speed of a particle on the star's equator? v
(b) What is the magnitude of the particle's centripetal acceleration? a_c
(c) If the neutron star rotates faster, do the answers to (a) and (b) increase, decrease, or remain the same?

GIVEN

$r = 20\text{km}$

$T = 1\text{s}$

KNOWN

$S = r\theta = (20\text{km})(2\pi)$

$= 1.3\times 10^2 \text{ km rad}$

a) $\boxed{v = \frac{ds}{dt} = \frac{\Delta s}{\Delta T} = 1.3\times10^2 \text{ km [rad] s}^{-1}}$

$\frac{ds}{dt} = r\frac{\partial\theta}{\partial t}$

$v = r\omega$

b) $\vec{a}_c = -r\omega^2\hat{r}$

$= -r\left(\frac{v}{r}\right)^2\hat{r}$

$= \frac{v^2}{r}\hat{r}$

$= \frac{(1.3\times10^5 \text{ m [rad] s}^{-1})^2}{2\times10^4 \text{ m}} \approx 8.5\times10^5 \text{ m s}^{-2}$ [rad].

c) if faster, T smaller, v larger

" " , a_c larger

Problem 3

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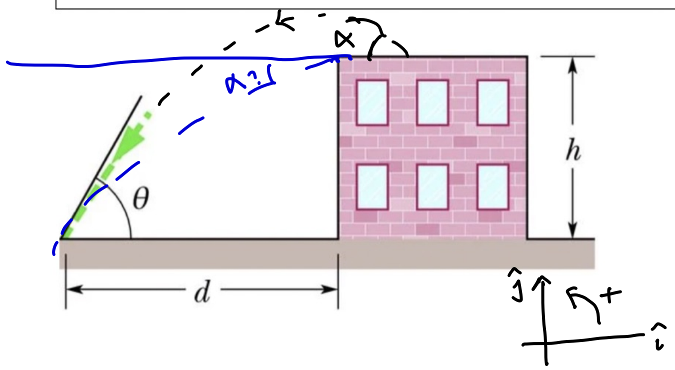


GIVEN
$t = 1.50\,s$
$S_x = -25.0\,m$
$\theta = 60°$

HORIZONTAL	VERTICAL
$S_x = -25.0\,m$	$S_y = -32\,m$
$U_x = -17\ ms^{-1}$	$U_y = -14\ ms^{-1}$
$V_x = -17\ ms^{-1}$	$V_y = -29\ ms^{-1}$
$a_x = 0\ ms^{-2}$	$a_y = -9.81\ ms^{-2}$

$t = 1.50s$

a) $h = 32m$

b) $u = \sqrt{U_x^2 + U_y^2} = 22\ ms^{-1}$

c) $\alpha = -40°$

d) below [NOTE U_y is -ve]

EQNS OF MOTION: HORIZONTAL

- $S_x = U_x t + \frac{1}{2}\cancel{a_x}_{=0} t^2 = U_x t \quad \therefore U_x = \frac{S_x}{t} \quad \therefore \boxed{U_x = -17\ ms^{-1}}$
- $V_x = U_x + \cancel{a_x}_{=0} t = U_x \quad \therefore \boxed{V_x = -17\ ms^{-1}}$

EQNS OF MOTION: VERTICAL

- $S_y = U_y t + \frac{1}{2} a_y t^2 = U_y t - \frac{1}{2} g t^2$
  → We know g, t. We don't know U_y
- $V_y = U_y + a_y t = U_y - gt$ → again, U_y unknown

FIGURING OUT U_y:

$U_y = U \sin\alpha \qquad V_y = V\sin\theta$

$U_x = U\cos\alpha \qquad V_x = V\cos\theta$

WE KNOW $U_x = V_x$!

$U_x = V_x$
$-17\,ms^{-1} = -17\,ms^{-1}$
$U\cos\alpha = V\cos\theta$
$U\cos\alpha = V\cos 60.0°$
$\frac{-17\,ms^{-1}}{\cos 60°} = V$

$V = \frac{-17\,ms^{-1}}{\cos 60°} \quad \therefore V = -34\,ms^{-1}$, V is a magnitude so $\boxed{V = 34\ ms^{-1}}$

WE KNOW $V_y = V\sin\theta$

$V_y = (-34\,ms^{-1})\sin 60°$ so $\boxed{V_y = -29\ ms^{-1}}$

Finally, $V_y = U_y + a_y t \quad \therefore U_y = V_y - a_y t$

$\therefore U_y = (-29\,ms^{-1}) - (-9.8\,ms^{-2})(1.50s)$

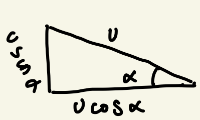
So, $\boxed{U_y = -14\ ms^{-1}}$

SOLVING FOR S_y: $\quad S_y = U_y t + \frac{1}{2} a_y t^2$

$\therefore S_y = (-14\,ms^{-1})(1.5s) + (0.5)(-9.8\,ms^{-2})(1.5s)^2$

so, $\boxed{S_y = -32\,m}$

HOW ABOUT α ?



$\sin\alpha = opp/hyp = \frac{U_y}{U} = \frac{-14\,ms^{-1}}{22\,ms^{-1}}$

so, $\alpha = \sin^{-1}\left(\frac{-14}{22}\right) = -0.69\,rad = -40°$