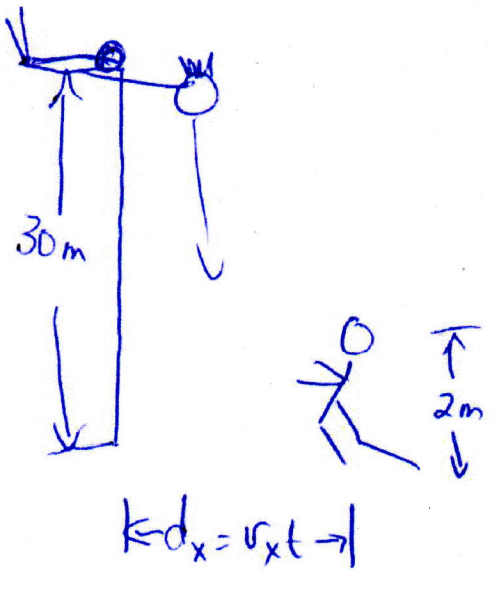
Phy 101 Motion Problems

1. Balloon Fight ! You want to drop a water balloon on a friend who is out jogging at 1.6 m/s. If the residence hall is 30 meters high, how far away from the target spot should your friend be when you drop the balloon?



Find t from vertical drop time.

$d = 30 - 2m = 28m$

$d = \frac{1}{2} a t^2$

$28m = \frac{1}{2} (9.8 m/s^2) t^2$

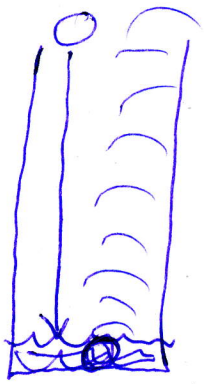
$t^2 = \frac{2(28m)}{9.8 m/s^2} = 5.71 sec^2$

$\boxed{t = 2.39 sec}$

$d_x = v_x t = 1.6 m/s \ (2.39 sec) = \boxed{3.82m = d_x}$

2. Your kid Brother drops a coin into a wishing well. After 2.078 seconds, you and he hear the "plopping" sound as the coin hits the water. How deep is the well?

The speed of sound is 344 m/s at 20°C.



$d_{down} = \frac{1}{2} a t_{down}^2$ where $a = 9.8 m/s^2$

$d_{up} = v_{sound} t_{up}$

$T_{total} = t_{down} + t_{up} = 2.078 sec.$

$d_{down} = d_{up}$

$\frac{1}{2} a t_{down}^2 = v_{sound} t_{up}$

Subst.

$T_{tot} - t_{down} = t_{up}$

$\frac{1}{2} a t_{down}^2 = v_{sound} (T_{tot} - t_{down})$

$0 = \frac{1}{2} a t_{down}^2 + v t_{down} - v T_{tot}$ ⇐ quadratic

$t_{down} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$a = 4.9$, $b = 344$, $c = 714.832$

2.) (cont)

$$t_{down} = \frac{-344 \pm \sqrt{(344)^2 + 4(4.9)(714.832)}}{2(4.9)}$$

$$= \frac{-344 \pm 363.795}{9.8}$$

* have to choose positive value for real, physical answer — time is positive.

$$\boxed{t_{down} = 2.02 \text{ sec.}}$$

$$\therefore \quad d_{down} = \frac{1}{2} a t^2$$

$$= \frac{1}{2} (9.8 \text{ m/s}^2)(2.02 \text{ sec})^2$$

$$= 20 \text{ m}$$

$$t_{up} = T_{tot} - t_{down} = 2.078 - 2.02 = 0.058 \text{ sec} = t_{up}$$

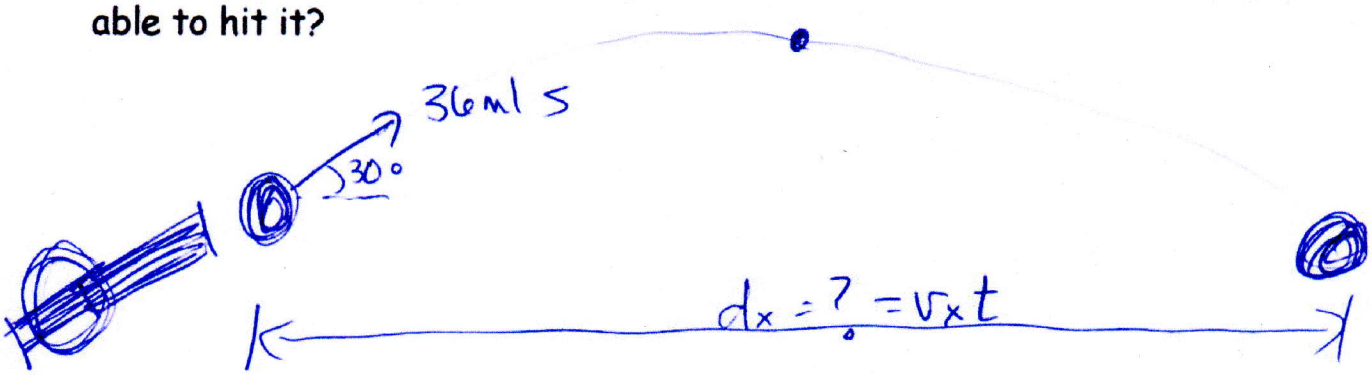
$$d_{up} = v_{sound}\, t_{up}$$

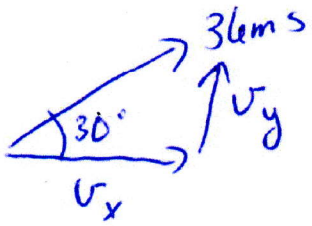
$$= 344 \text{ m/s} \, (0.058 \text{ sec})$$

$$= 20 \text{ m}$$

Well depth (to water level) = 20 m

3. Cannon Balls Away! Galileo is testing cannons by holding a cannon shooting contest. If the cannon you have is shot at a 30 degree angle with a velocity of 36 m/s, how far away could the target be located from the cannon and you still be able to hit it?





Find v_y & v_x

$v_y = v \sin\theta = 36\,m/s \sin 30 = 18\,m/s$

$v_x = v \cos\theta = 36\,m/s \cos 30 = 31.2\,m/s$

Find time in air from vertical info.

$v_{fy} - v_{iy} = at$ $\quad t = \dfrac{0 - 18\,m/s}{-9.8\,m/s^2} = 1.84\,sec.$

Double time to peak of flight for full time

$t_{total} = 3.68\,sec$

Total horizontal distance

$d_x = v_x t_{total} = 31.2\,m/s\,(3.68\,sec)$

$d_x = 114.6\,m$

4. The tortoise and the hare! The tortoise and the hare are having a race. Hare expects to win easily and so doesn't line up quickly. Tortoise starts off from the start line accelerating at 0.03 m/s^2 for 20 seconds, then continues at that speed for 120 seconds. If Hare finally leaves 50 seconds later and accelerates at 0.5 m/s^2 for 5 seconds, and then continues at that pace, when will he catch up with tortoise? How far will they both have traveled by then?

This is a tricky problem, so simply explain how you would set up the problem to solve for the information requested. Draw diagrams to assist in your explanation.

Tortoise

d_1 d_2

$v_i = 0$ $v_{f1} = at = v_{tor}$ $d_{tor} = v_{tor} t_{tor}$

$t_1 = 0$ $t_2 = 20\,sec$ $t_3 = t_{tor}$

Hare

d_3 d_4

$t_1 = 0$ $t_2 = 50\,sec$ $t_3 = 5\,sec$ $d_{hare} = v_{hare} t_{hare}$

$v_i = 0$ $v_{hare} = a t_3$ $t_4 = t_{hare}$

$d = 0$ $t_{sub\ total} = 55\,sec$ $t_{total} = 55\,sec + t_{hare}$

Hare passes tortoise IS/when:

1.) $d_{TOTAL\ hare} = d_{Total\ tortoise}$

2.) $t_{TOTAL\ hare} = t_{TOTAL\ tortoise}$

4.) (cont.)

To solve:

a) set two distances equal & find t_{total}, then d_{total} for each animal

b) Use times for each animal to solve for each total d.

Should be equal!