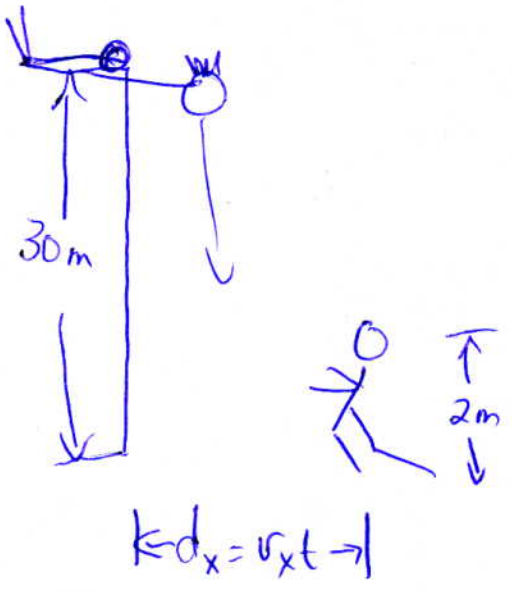
Phy 101 Motion Problems

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.

$d = 30 - 2m = 28m$

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

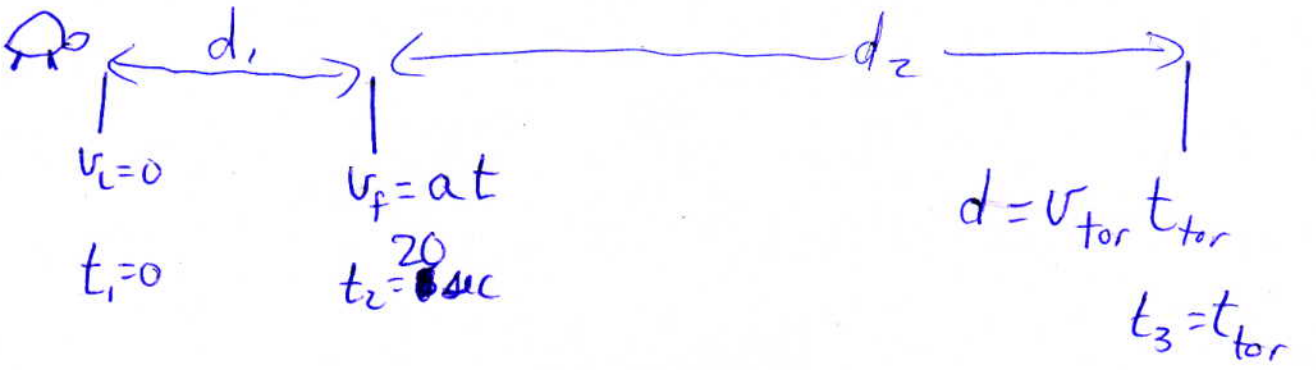
$28m = \frac{1}{2} (9.8 m/s^2) t^2$

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

$t = 2.39 sec$

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

2. 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?



Tortoise

First distance

$$d_1 = \frac{1}{2} a t^2$$

$$= \frac{1}{2} 0.03 m/s^2 (20 sec)^2$$

$$\boxed{d_1 = 6 m}$$

$$v_f = at$$

$$= 0.03 m/s^2 (20 sec)$$

$$\boxed{v_{tor} = 0.6 m/s}$$

Total distance tortoise goes

$$d_{tor} = d_1 + d_2 = 6m + v_{tor} t_{tor}$$

Total time tortoise goes

$$t_{TOTAL\ tor} = 20 sec + t_{tor}$$

Q2.

Hare

d_3 | d_4

$t_1 = 0$ $t_2 = 50\,sec$ $t_3 = 55\,sec$ $t_4 = t_{hare}$

$v_i = 0$ $v_{hare} = at$ $d_{hare} = v_{hare} t_{hare}$

Sits still for 50 sec.

First distance

$$d_3 = \frac{1}{2} a t^2$$

$$= \frac{1}{2} 0.5 m/s^2 (5 sec)^2$$

$$\boxed{d_3 = 6.25 m}$$

$$v = at$$

$$= 0.5 m/s^2 (5 sec)$$

$$\boxed{v_{hare} = 2.5 m/s}$$

Total distance hare goes

$$d_{hare} = d_3 + d_4 = 6.25 m + v_{hare} t_{hare}$$

Total time hare goes

$$t_{TOTAL\ hare} = 50 sec + 5 sec + t_{hare}$$

(Q2.)

Hare passes tortoise if/when:

1.) $d_{TOTAL}^{hare} = d_{TOTAL}^{tortoise}$

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

Set two distances equal & find t_{TOTAL} then d_{TOTAL}

$d_{hare} = 6.25\,m + v_{hare}\, t_{hare} = 6\,m + v_{tor}\, t_{tor}$

Substitute for $t_{tor} = t_{total} - 20\,sec.$

$t_{hare} = t_{total} - 55\,sec$

$d = 6.25\,m + v_{hare}(t_{TOTAL} - 55\,sec) = 6\,m + v_{tor}(t_{TOTAL} - 20\,sec)$

Solve for t_{TOTAL}

$t_{TOTAL}(v_{hare} - v_{tor}) = 6\,m - 6.25\,m + v_{hare}(55\,sec) - v_{tor}(20\,sec)$

$1.9\,m/s\; t_{TOTAL} = 125.25\,m \Longrightarrow \boxed{t_{TOTAL} = \frac{125.25\,m}{1.9\,m/s} = 65.9\,sec}$

Q2

Check answer

Hare $t_{TOTAL} = 65.9\,sec = 55\,sec + t_{hare}$

$t_{hare} = 10.9\,sec$

Tortoise $t_{TOTAL} = 65.9\,sec = 20\,sec + t_{tor}$

$t_{tor} = 45.9\,sec$

Distance at which hare catches tortoise

$d_{hare} = 6.25\,m + v_{hare}\, t_{hare}$

$= 6.25\,m + 2.5\,m/s\,(10.9\,sec)$

$\boxed{d_{hare} = 33.5\,m}$

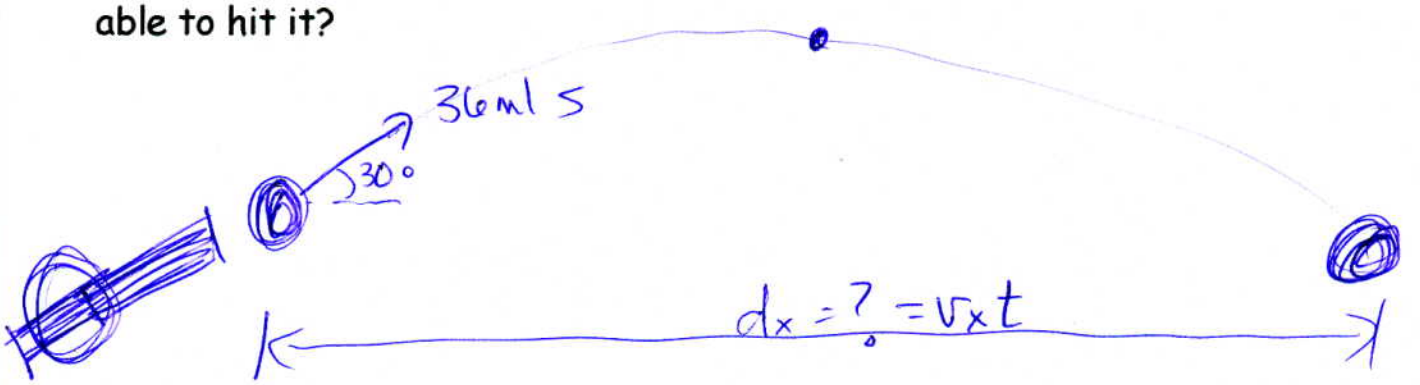
Match!

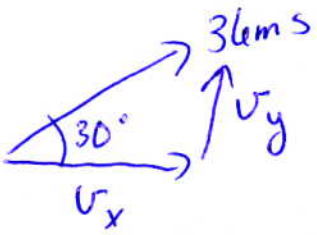
$d_{tor} = 6m + v_{tor}\, t_{tor}$

$= 6\,m + 0.6\,m/s\,(45.9\,sec)$

$\boxed{d_{tor} = 33.5\,m}$

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

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

$d_x = 114.6 m$