Physics 8.01L Pset # 3 — Solutions

3-1)

a)

35.0m

$\xrightarrow{1.0ms^{-1}}$

$\xrightarrow{1.5ms^{-1}}$

Net velocity is $\xrightarrow{2.5ms^{-1}}$

$v = \frac{d}{t}$, $t = \frac{d}{v}$

$= \frac{35.0m}{2.5ms^{-1}}$

$\boxed{= 14.0s}$

b)

$\xrightarrow{1.0ms^{-1}}$

$\xleftarrow{1.5ms^{-1}}$

Net velocity $\xleftarrow{0.5ms^{-1}}$

35.0m

$t = \frac{35.0m}{0.5ms^{-1}}$ $\boxed{= 70s}$

Goal: Addition of vector velocities.

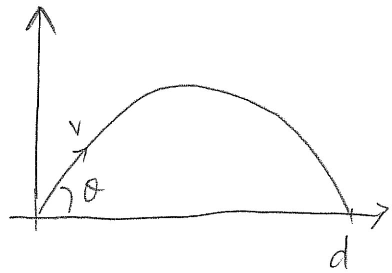
All vectors are in 1 dimension, so we can just add and subtract the relevant velocities.

When in the same direction, the magnitudes add.

When in opposite direction, subtract one from the other.

Note that in second case, the woman begins from opposite end of sidewalk.

3-2)



Gravity in accelerator $= -g + g/5 = -\frac{4}{5}g$

$\Rightarrow$ Normal acceleration experienced, except that now reduced to $4/5$ of value.

(Denoting coordinates in elevator with primes '),

$v_y = at$, t = time of flight for half the trajectory

Since v_y does not change in the elevator,

$$a't' = at$$

$$\Rightarrow t' = \frac{a}{a'}t = \frac{g}{4/5 g}t = \frac{5}{4}t$$

Since both halves of the trajectory are mirror reflections, the total time of flight changes by the same factor $T' = \frac{5}{4}T$

Since $v_x = \frac{d}{T} \Rightarrow T = \frac{d}{v_x}$,

the time of flight is proportional to distance travelled, $\Rightarrow$ distance travelled $= \boxed{\frac{5}{4}d}$

Goal: Analyze motion in accelerating inertial frame.

A frame accelerating downward is equal to a gravitational force acting upward (principle of equivalence), $\Delta g = g/5$

The "weaker" gravity causes a longer time of flight, $t' = \frac{5}{4}t$

The longer time of flight increases the horizontal distance travelled by the same factor, $d' = \frac{5}{4}d$

3-3) $\vec{F} = m\vec{a}$

$= m\dfrac{d\vec{v}}{dt}$

$\Rightarrow$ Force is the slope of a v-t graph

a) Maximum force = steepest slope

$F = m\dfrac{\Delta v}{\Delta t} = 2.75 \cdot \dfrac{8.0}{2.0}$

$\boxed{= 11\ N}$.

It occurs between $\boxed{0 < t < 2.0\ s.}$

b) Net force = zero when slope = 0

Slope is zero when $\boxed{2.0s < t < 6.0s}$

c) At $t = 8.5s$, the slope can be found by taking the average slope over that constant region.

$F = m\dfrac{\Delta v}{\Delta t} = 2.75 \times \dfrac{(12-8)}{(10-6)}$

$= 2.75 \times \dfrac{4}{4}$

$\boxed{= 2.75\ N}$

Goal: Reading force information from a velocity graph.

Distinguish between slopes of graph, at different points.

Instantaneous slope = average slope if slope is constant.

3-4) For $(t, N) = \begin{cases} (0, 100) \\ (2, 150) \end{cases}$,

input into $F = A + Bt^2$,

$\Rightarrow 100 = A$,

and $150 = A + B(2^2)$

$50 = 4B, \quad B = 12.5$

$\Rightarrow \boxed{A = 100\ N, \quad B = 12.5\ N s^{-2}}$

(b) (i) When fuel ignites, $F = A = 100N$

total force $= F - mg$

$= 100 - 8 \times 9.8 = \boxed{21.6N}$

Acceleration $= F/m = 21.6/8 = \boxed{2.7 ms^{-2}}$

(ii) At $t = 3$, $F = A + B \cdot 3^2$

$= 100 + 9 \times 12.5$

Total force $= F - mg$

$= 100 + 9 \times 12.5 - 8 \times 9.8$

$\boxed{= 134\ N}$

Acceleration $= 134/8 = \boxed{16.8\ ms^{-2}}$

(c) $F = 100 + 9 \times 12.5$

Acceleration $= F/m = \frac{1}{8}(100 + 9 \times 12.5)$

$\boxed{= 26.6\ ms^{-2}}$

Goal: Calculating the force on the rocket from two sources, one of them time-dependent

We include gravity to find the net force.

Acceleration $= \dfrac{\text{Force}}{\text{mass}}$

In outer space, rocket feels only force F