Tutorial #3

P1 ▫ Plot show a plotted versus m. From Newton's 2nd Law:

· $F = ma \Rightarrow a = \frac{F}{m}$ (so we expect the inverse relationship as shown)

▫ When $m = 600g = 0.6\,kg$, $a = 6\,\frac{m}{s^2} \rightarrow F = ma = (0.6)(6) = 3.6\,N$
(Note: we could have used other value pairs and obtained same answer)

P2 ▫ $\bar{r} = x\hat{i} + y\hat{j} = (\frac{1}{2}t^3 - 2t^2)\hat{i} + (\frac{1}{2}t^2 - 2t)\hat{j}$ [m]

a When $t = 0$, $x = y = 0 \rightsquigarrow \bar{r} = 0$ (i.e. it is at the origin)
when $t = 4$, $\frac{1}{2}(64) - 2(16) = 0 \rightsquigarrow x = y = 0 \rightsquigarrow \bar{r} = 0$

so $\boxed{\bar{r}(0) = \bar{r}(4) = 0}$

▫ $\bar{v} = \frac{d}{dt}\bar{r} = \frac{d}{dt}\left[(\frac{1}{2}t^3 - 2t^2)\hat{i} + (\frac{1}{2}t^2 - 2t)\hat{j}\right]$

$= \cancel{(\frac{3}{2}t^2 - 4t)\hat{i} + (t-2)\hat{j}} = (\frac{3}{2}t^2 - 4t)\hat{i} + (t-2)\hat{j}$

$\bar{v}(t=0) = (0)\hat{i} + (0-2)\hat{j} \rightsquigarrow \boxed{\underbrace{\bar{v}(0) = -2\hat{j}}_{\text{velocity}}} \Rightarrow \underbrace{|\bar{v}| = 2\,\frac{m}{s}}_{\text{speed}}$

$\bar{v}(t=4) = (\frac{3}{2}\cdot 16 - 16)\hat{i} + (4-2)\hat{j} \rightsquigarrow \bar{v}(4) = 8\hat{i} + 2\hat{j}$

$\boxed{|\bar{v}(4)| = \sqrt{8^2 + 2^2} \simeq 8.3\,\frac{m}{s}}$

b "direction of motion" mean what direction does $\bar{v}$ point in.
Let "$\angle\bar{v}$" mean the "angle of $\bar{v}$ re positive x-axis"

▫ At $t = 0$, $\bar{v}(0) = -2\hat{j}$ (i.e. along $-y$ axis) $\Rightarrow \boxed{\angle\bar{v}(0) = -90°\ (\text{or } -\frac{\pi}{2})}$

▫ At $t = 4$, $\angle\bar{v}(4) = \tan^{-1}(\frac{2}{8}) \Rightarrow \boxed{\angle\bar{v}(4) \simeq 14°\ (\text{or } 0.25 \text{ rads})}$

P3 ☐ Constant force (call it F_o) on mass m leads to $10\ m/s^2$ acceleration.

Or via Newton's 2nd Law: $F_o = 10m \rightarrow \frac{F_o}{m} = 10\ m/s^2$

a) $F_o \rightarrow \frac{F_o}{2}$: $\frac{F_o}{2m} = \frac{1}{2}(10) = \boxed{5\ m/s^2}$

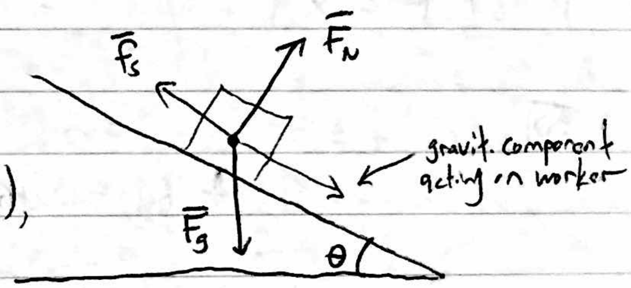
b) $m \rightarrow \frac{m}{2}$: $\frac{F_o}{m/2} = 2(10) = \boxed{20\ m/s^2}$

c) $F_o \rightarrow \frac{F_o}{2}$ AND $m \rightarrow \frac{m}{2}$: $F_o/2 \big/ (m/2) = \frac{(\frac{1}{2})}{(\frac{1}{2})} \frac{F_o}{m} = \boxed{10\ m/s^2}$

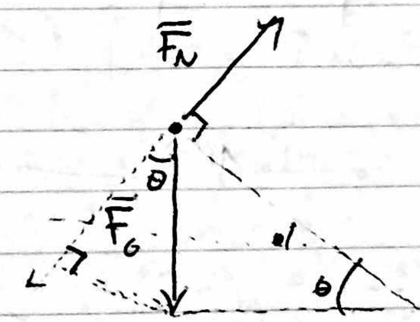
d) $F_o \rightarrow \frac{F_o}{2}$ AND $m \rightarrow 2m$: $\frac{F_o/2}{2m} = \frac{1}{4} \frac{F_o}{m} = \boxed{2.5\ m/s^2}$

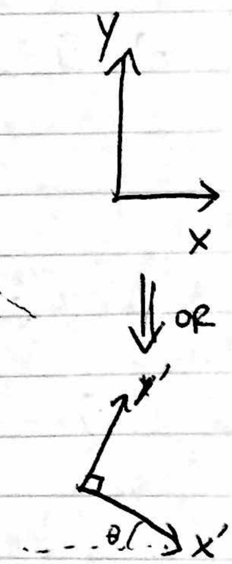
P4 $W = 850\ N$ (weight of worker) $= mg$

$\Rightarrow \bar{F}_g = -850\hat{y}$



<u>NOTE</u>: If worker is standing (i.e. not moving), there must be a (static) frictional force. But we don't need to consider that component directly here





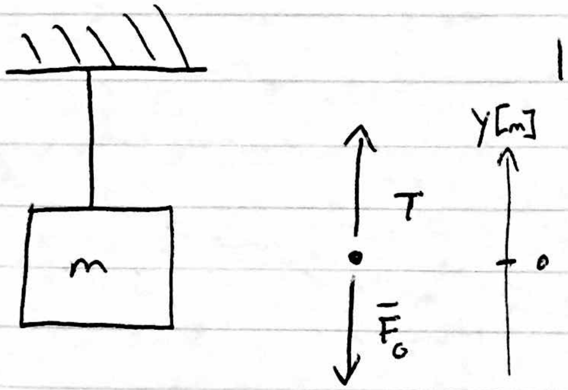
☐ Note "rotated" x'-y' coord axes to right. Then along the y' axis, we have:

$$\Sigma F_{y'} = 0 = \bar{F}_N + \bar{F}_G \cos\theta$$
$$= m\bar{g}\cos\theta + \bar{F}_N$$

$$\rightarrow |\bar{F}_N| = (850)\cos 15 \simeq \boxed{799\ N}$$

<u>NOTE</u>: Simple reality check: Make sure $F_N \rightarrow F_G$ as $\theta \rightarrow 0$;.

P5



$|\bar{F}_g| = mg$ or $\bar{F} = mg\hat{y}$ $(g = -9.8\ m/s^2)$

a) at rest: $\Sigma F = 0 = \bar{F}_g + \bar{T}$

$\rightsquigarrow \bar{T} = -\bar{F}_g = -(50)(-9.8)\hat{y} = \boxed{490\hat{y}\ N}$

b) moving up at const. velocity $\Rightarrow 490\hat{y}$ N
(because net change in motion is zero, therefore $\Sigma F = 0$ like before)

c) $v_y = 5.0\ m/s$ (i.e. it is moving upward) and $a_y = +5.0\ m/s^2$

- Now there is a net force acting on the box that is positive (because it is accelerating upwards), meaning that the tension must be greater than before

$$\Sigma \bar{F} = m(5.0)\hat{y} = \bar{F}_g + \bar{T} = (50)(5)\hat{y}\ 250\hat{y} = -490\hat{y} + \bar{T}$$

$$\longrightarrow \boxed{\bar{T} = 740\hat{y}\ N}$$

d) $v_y = -5.0\ m/s$
$\rightsquigarrow$ similar to before but $\Sigma \bar{F} = -m(5.0)\hat{y}$

$$\rightsquigarrow \bar{T} - 490\hat{y} = -250\hat{y} \Rightarrow \boxed{\bar{T} = 240\hat{y}\ N}$$