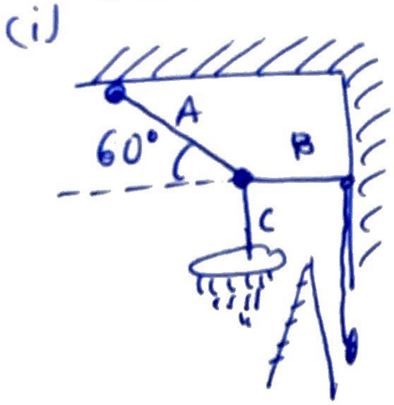
9B Statics {Under force, but No Acc'l'n}

①

- $$\boxed{\sum F = 0} \Leftarrow \left\{ \sum F = m\cancelto{0}{a} \right\}$$
- $$\boxed{\sum \tau = 0} \Leftarrow \left\{ \sum \tau = I\cancelto{0}{\alpha} \right\}$$

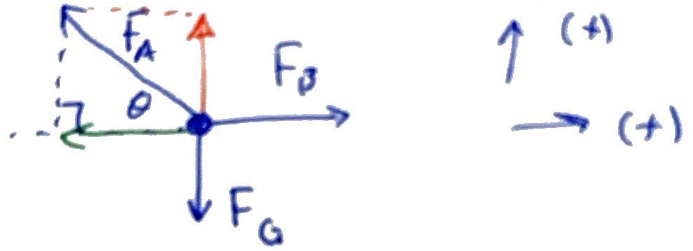
EX Consider a chandellier. what are the force in the cables that suppor the follow lamp below

(i)



(ii)

m = 200 kg
θ = 60°



(iii) $\sum \vec{F} = \vec{0}$

NOT Needed → $\sum \vec{\tau} = \vec{0}$

$x: F_{A_x} + F_{B_x} + F_{G_x} = 0$

$y: F_{A_y} + F_{B_y} + F_{G_y} = 0$

$\Rightarrow x: -F_A \cos\theta + F_B + 0 = 0 \rightarrow \boxed{F_B = F_A \cos\theta}$

$y: F_A \sin\theta + 0 - mg = 0 \rightarrow \boxed{F_A = mg/\sin\theta}$

(iv) Solve: F_A 1st: $F_A = \dfrac{(200\text{kg})(9.8\text{ m/s}^2)}{\sin(60°)}$

$$\boxed{F_A = 2263.2\text{ N}}$$

$F = 2263.2 \cos(60°)$

$F_B = 1131.6\text{ N}$

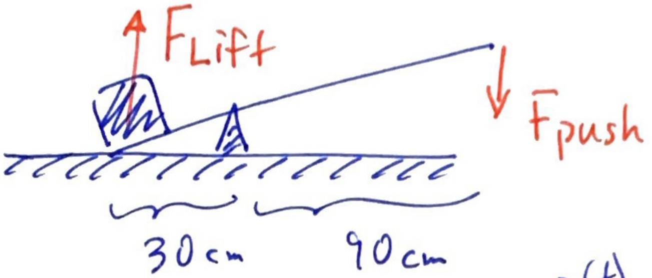
$F_A = \dfrac{(200)(9.8)}{\sin(5°)}$ → ⑴°

$F_A = 2\ 488N$

$2\ 000N$

ex Fulcrum Problem (Levers)

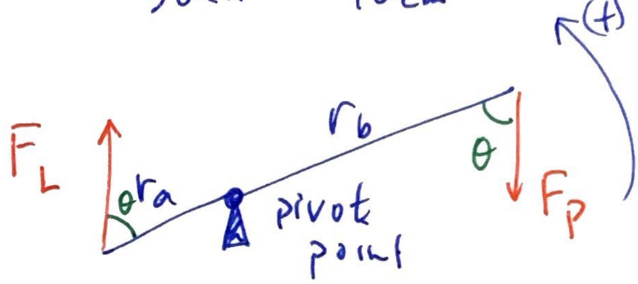
(i)



$W = 800\ N$

Q: What F_{push} do we need to lift the package?

(ii)



Data

$r_a = 0.30\,m$
$r_b = 0.90\,m$
$F_\ell = 800\ N$
$F_p = ?$

(iii) $\sum \vec{F} = \vec{0}$

$\boxed{\sum \vec{\tau} = \vec{0}}$ ← Start with this since rotation only.

$\boxed{\tau = r F_\perp \sin\theta}$

(v) $\tau_A + \tau_B = 0$

$$\overset{+}{-}\left[r_a F_L \sin\theta\right] + \left[\overset{+}{-} r_b F_p \sin\theta\right] = 0$$

clockwise "motion"

$$\Rightarrow -r_a F_\ell \cancel{\sin\theta} - r_b F_p \cancel{\sin\theta} = 0$$

$$\Rightarrow F_p r_b = -r_a F_\ell$$

$$\Rightarrow \boxed{F_p = -\left(\frac{r_a}{r_b}\right) F_{Lift}}$$

apply to our case

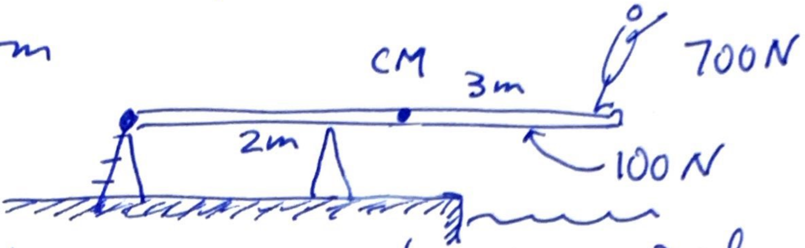
$$F_{push} = -\left(\frac{30\,cm}{90\,cm}\right)(800\ N)$$

$\boxed{F_p = -270\ N}$ push down to lift 800N

ex use both torque and Force sums.

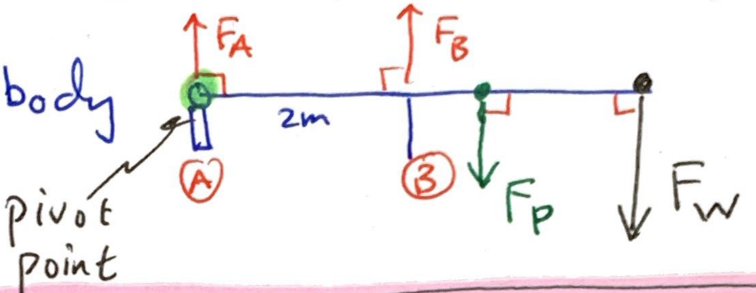
Diving Platform

(i)



Q: Find the Forces on the two pylons

(ii) Free body



(+)

F_p = platform

(iii) y: $\sum F_y = 0 \Rightarrow \boxed{F_A + F_B - F_p - F_W = 0}$

x: $\sum F_x = 0$ not applicable {No x-components}

τ: $\sum \tau = 0 \Rightarrow \tau_A + \tau_B + \tau_p + \tau_W = 0$

$\boxed{\tau = rF\sin\theta}$

$$\boxed{\cancelto{0}{0 F_A \sin 90°} + 2m\, F_B \sin 90° - 2.5m\, F_p \sin 90° - 5m\, F_W \sin 90° = 0}$$

2 eqns and 2 unknowns F_A and F_B

(iv)

τ: $2F_B - 2.5F_p - 5F_W = 0$

$2F_B = 2.5F_p + 5F_W$

$F_B = \left(\frac{2.5}{2}\right)(100N) + \left(\frac{5}{2}\right)(700N)$

$\boxed{F_B = 1875N}$

- what about F_A ?

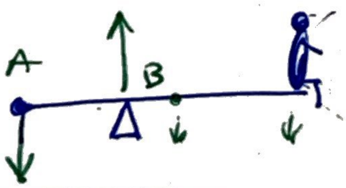
use y: $F_A + F_B - F_p - F_W = 0$

$F_A = F_p + F_W - F_B$

$F_A = 100N + 700N - (1875N)$

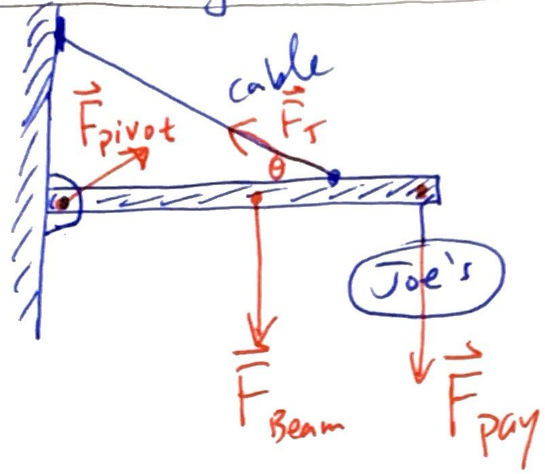
$\boxed{F_A = -1075N}$

down!!!



⊛ Street-Sign Problem

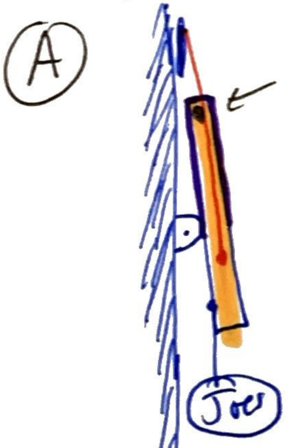
EX



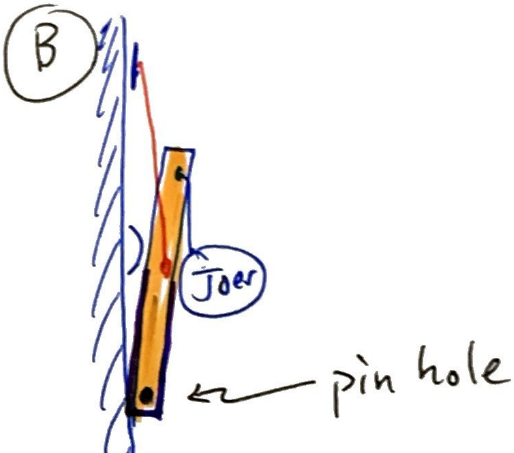
we know $F_{payload}$ W_{Beam}, we want the Tension in the Cable and the $\vec{F}_{pivot}$.

<u>Thought</u>: Remove the pin in the wall mount.

Two possible scenarios:

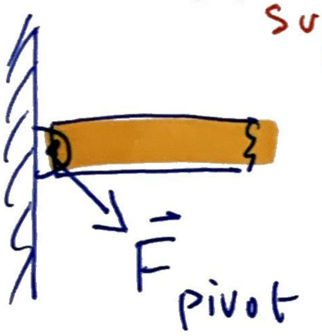


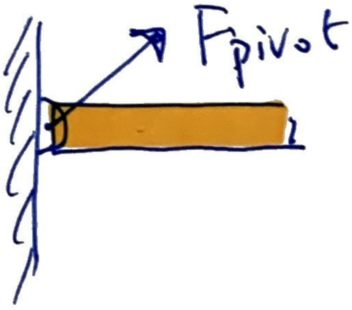
OR



Heavy Sign or Closer Cable support

Heavy Beam





$F_y < 0$

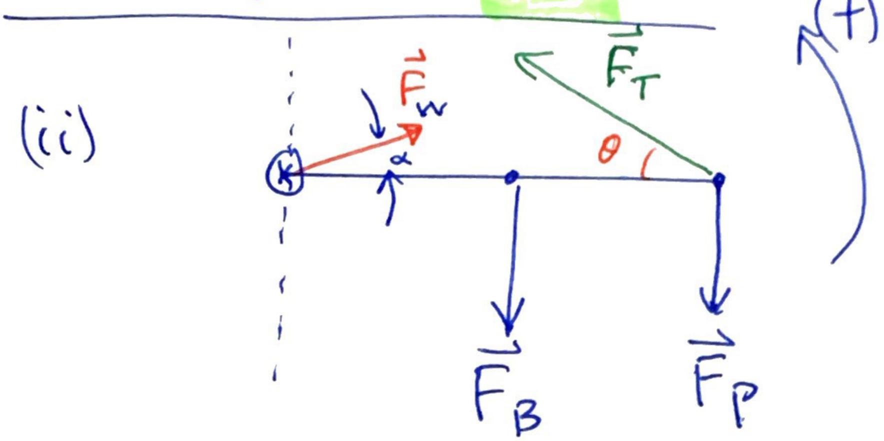
$F_y > 0$

The math will tell us which happens.

cont.

Find $\vec{F}_T$ and $\vec{F}_W$

(ii)



$l = 2.2\, m$

$m_B = 25\, kg$

$m_p = 28\, kg$

$\theta = 30°$

$F_T = ?$

$\vec{F}_W)_x = ?$

$\vec{F}_W)_y = ?$

(iii) $\boxed{\sum \vec{\tau} = 0 \quad , \quad \sum \vec{F} = 0 \begin{cases} \sum F_x = 0 \\ \sum F_y = 0 \end{cases}}$

(iv) $\boxed{\tau: \quad \underset{0}{\tau_W} + \tau_B + \tau_p + \tau_T = 0}$

$\Rightarrow \cancel{r_W} F_W \sin(\alpha) - r_B F_B \sin 90° + r_p F_p \sin 90° + r_T F_T \sin 30° = 0$

$\Rightarrow -\left(\frac{l}{2}\right) F_B \cdot 1 - l F_p \cdot 1 + l \boxed{F_T} \sin\theta = 0$

weight of Beam causes clock-wise rot'n.

• we only have F_T as an unknown

$\Rightarrow \cancel{l} F_T \sin\theta = \frac{\cancel{l}}{2} F_B + \cancel{l} F_p$

$F_T = (F_B/2 + F_p)/\sin\theta$

$F_T = \left(\frac{(25\,kg)(9.8)}{2} + (28\,kg)(9.8)\right)/\sin 30°$

$\boxed{F_T = 793.8 N} \approx 800 N$

we are left with $F_W)_x$ & $F_W)_y$

N. x-compont

X: $F_W)_x + \cancel{F_B)_x}^{\to 0} + \cancel{F_P)_x}^{\to 0} + F_T)_x = 0$

points in (−) x direction

$$\to F_W)_x - F_T \cos\theta = 0$$

$$= (793.8N)\cos(30°)$$

$$\boxed{F_{W_x} = 687.45N}$$

✓ ✓ ✓

y: $F_w)_y + F_B)_y + F_P)_y + F_T)_y = 0$

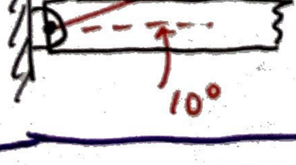
$$F_W)_y = -F_B)_y - F_P)_y - F_T)_y$$

$$F_W)_y = -\underbrace{(25)(9.8)}_{N} - (\underbrace{28kg)(9.8}_{N}) - (793.8N)\sin 30°$$

$$\boxed{F_W)_y = 122.5N}$$

⟹ BTW: removing the pin will result in scenario (B): "scrapdown wall"

- Magnitude of $\|\vec{F}_W\| = \sqrt{687.45^2 + 122.5^2}$
  $= \boxed{698.3N}$
- Direction: (α)



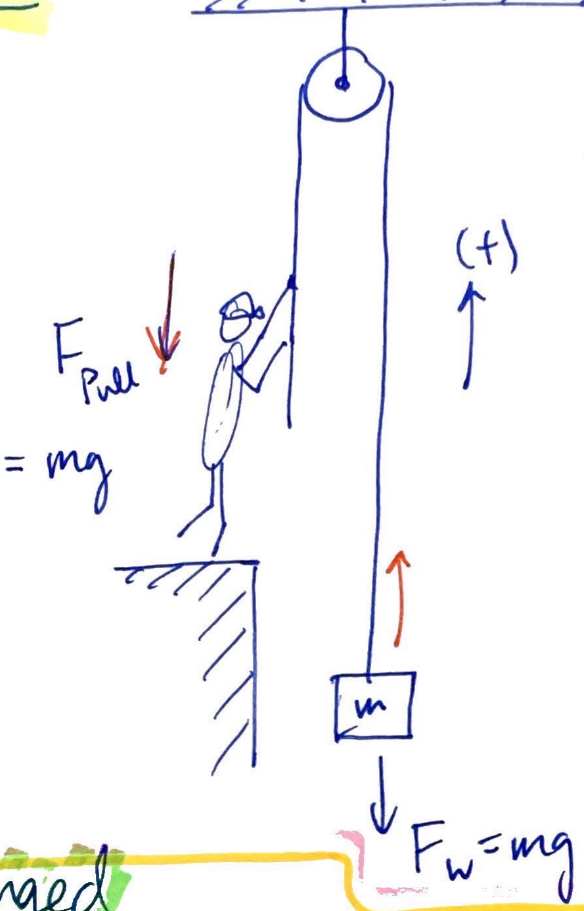
$$\alpha = \tan^{-1}\left(\frac{122.5N}{687.45N}\right)$$

$\boxed{\alpha = 10.1°}$ North of East (up)

⊗ pulleys

• Single

No Advantage



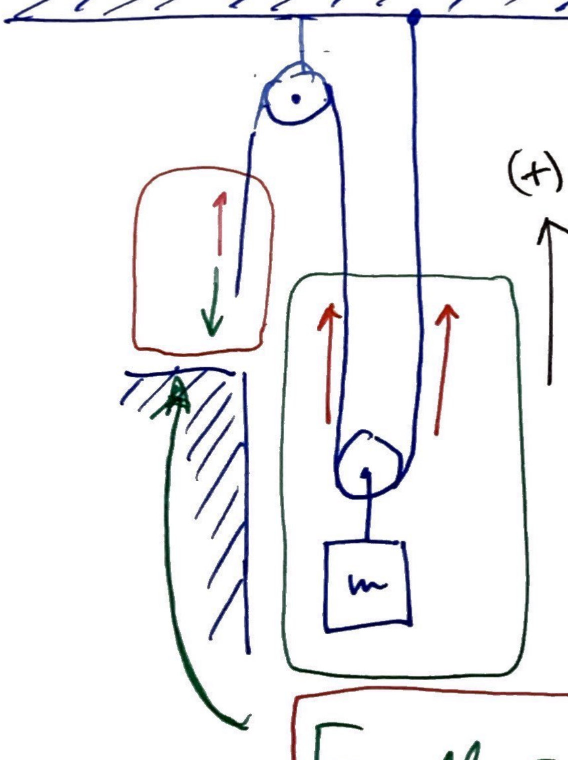
- Pull one foot down the crate moves one foot up
- I need to pull mg newtons down to get the packet to go up.
- $\sum F = 0$

$$-F_{pull} + F_W = 0$$

$$\boxed{F_{pull} = F_W}$$

• ganged

Has an advantage



- $\sum F = 0$

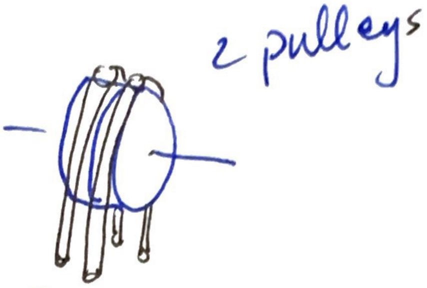
$$2F_T - F_W = 0$$

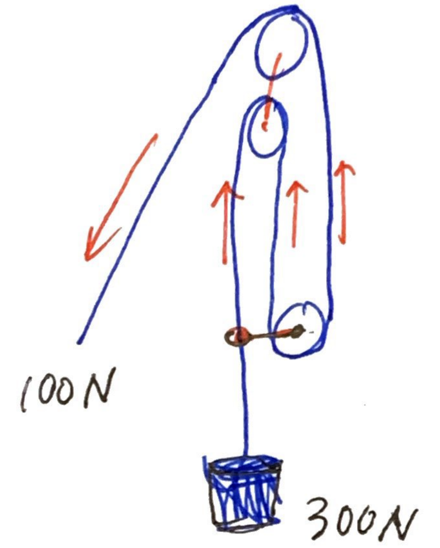
$$F_T = \frac{1}{2} F_W$$

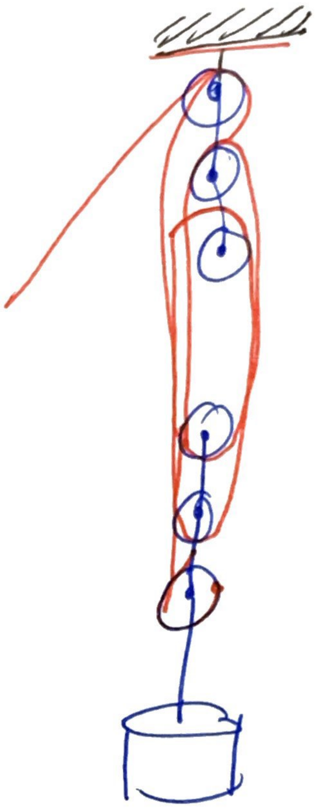
- pull down $\frac{1}{2}$ the weight
- pull through 2ft to get box to rise 1ft.

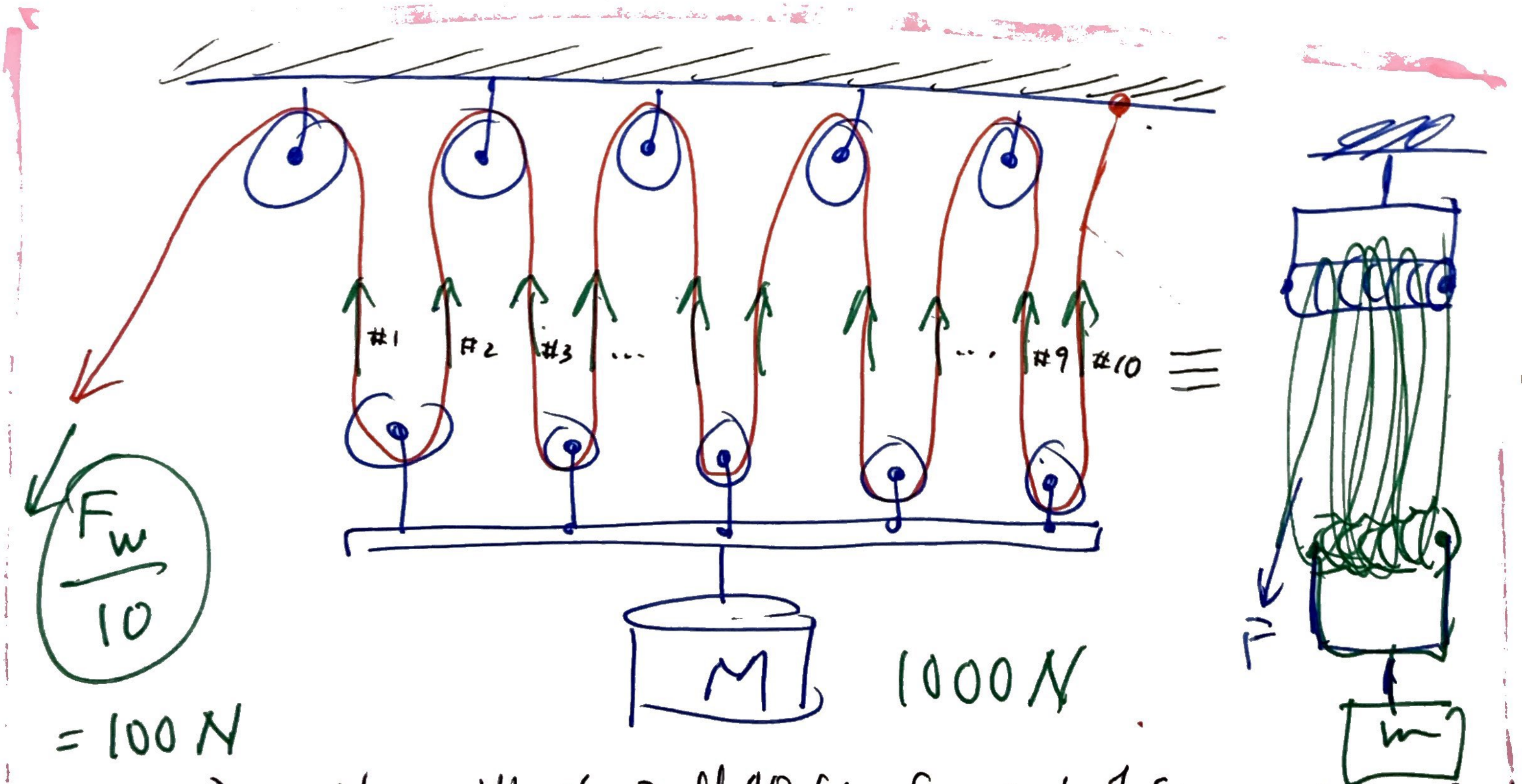
$$\boxed{F_{pull} = F_T = \frac{1}{2} F_W}$$

Ⓐ More pulleys









Downside: Must pull 10 ft for each 1 ft rise in payload