2/20/2018 LECTURE NOTES

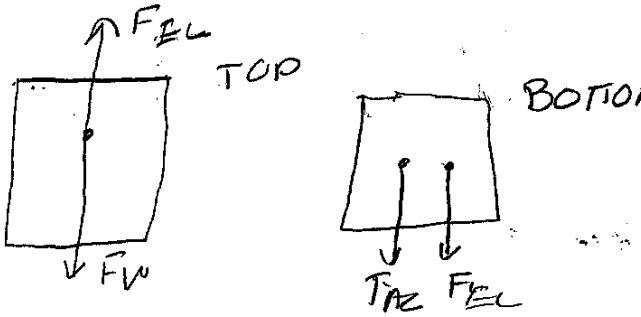
NEWTON'S THREE LAWS

1ST → INERTIA

2ND → $\Sigma \vec{F} = m\vec{a} = \Sigma F_x \hat{i} + \Sigma F_y \hat{j} + \ldots = m\vec{a} \Rightarrow kg\,m/s^2$

3RD → ACTION / REACTION $|\vec{F}_{AB}| = |\vec{F}_{BA}|$ $= \frac{\Delta \vec{p}}{\Delta t} \rightarrow N$ → IMPULSE

ELEVATOR - FREE BODY DIAGRAM



$F_{EL} = ma_{EL}$

$F = -mg$

$\Sigma F_y = ma_y$ ∴ $F_x = 0$

↑ P : $(ma_{EL} - mg) = ma_y$

$m(a_{EL} - g) = ma_y$

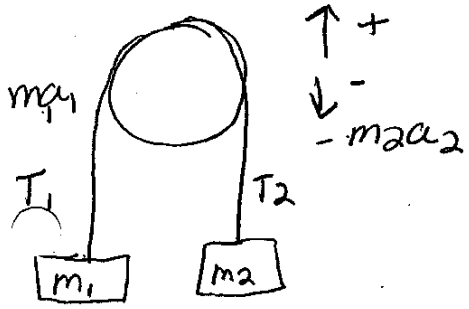
$\boxed{a_{EL} - g = a_y}$

Bottom : $ma_{EL} - mg = -ma_y$

$-m(a_{EL} + g) = -ma_y$

$\boxed{a_{EL} + g = a_y}$

PULLY



WEIGHTLESS PULLY + STRING

$T_1 = T_2$

$\Sigma F_{y_1} = T - m_1 g = m_1 a$; $\Sigma F_{y_2} = T - m_2 g = -m_2 a$

$\frac{T - m_1 g}{m_1} = \frac{m_1 a}{m_1}$

$\frac{T}{m_1} - g = a$

$T - m_2 g = -m_2 \left(\frac{T}{m_1} - g\right)$

$T - m_2 g = -\frac{m_2}{m_1} T + m_2 g$

$+m_2 g \quad +\frac{m_2}{m_1} T \quad +m_2 g$

$T + \frac{m_2}{m_1} T = 2 m_2 g$

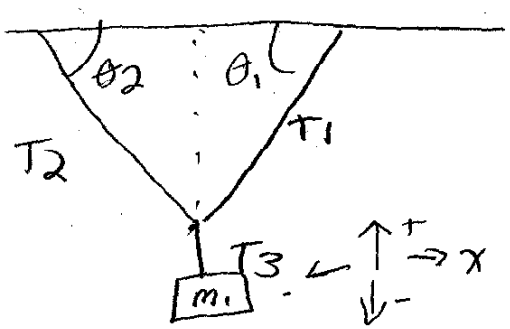
$\frac{m_1 T + m_2 T}{m_1} = 2 m_2 g\, m_1$

$m_1 T + m_2 T = 2 m_1 m_2 g$

$\frac{(m_1 + m_2)}{(m_1 + m_2)} = \frac{2 m_1 m_2 g}{(m_1 + m_2)}$

$$T = \frac{2 m_1 m_2 g}{(m_1 + m_2)}$$

STRING



$a = 0$ ∴ NO MOTION

$T_3 = -mg$

$\Sigma F_x = T_1 \cos\theta_1 - T_2 \cos\theta_2 = 0$

$\Sigma F_y = T_1 \sin\theta + T_2 \sin\theta_2 - mg = 0$

$$T_1 \cos\theta_1 - T_2 \cos\theta_2 = 0$$

$$+T_2 \cos\theta_2 = +T_2 \cos\theta_2$$

$$\frac{T_1 \cos\theta_1}{\cos\theta_1} = \frac{T_2 \cos\theta_2}{\cos\theta_1}$$

$$T_1 = T_2 \frac{\cos\theta_2}{\cos\theta_1}$$

$$\frac{T_2 \cos\theta_2}{\cos\theta_1} \sin\theta_1 + T_2 \sin\theta_2 = mg$$

$$T_2\left[\left[\frac{\cos\theta_2}{\cos\theta_1}\right]\sin\theta_1 + \sin\theta_2\right] = mg$$

$$T_2 = \frac{mg}{\left[\left[\frac{\cos\theta_2}{\cos\theta_1}\right]\sin\theta_1 + \sin\theta_2\right]}$$

$$T_1 = \frac{mg}{\left[\left[\frac{\cos\theta_2}{\cos\theta_1}\right]\sin\theta_1 + \sin\theta_2\right]}\left[\frac{\cos\theta_2}{\cos\theta_1}\right]$$

$$T_1 = \frac{mg\cos\theta_2}{\left[\cos\theta_2 \sin\theta_1 + \sin\theta_2 \cos\theta_1\right]}$$

EXAMPLE

A 70.00 KG PERSON IS TRAVELING IN 4,000 KG ELEVATOR. WHAT ARE THE TOP AND BOTTOM ACCELERATION IF THE ELEVATOR HAS $a_{EL} = 2.100\ m/s^2$. WHAT IS THE MASS OF THE COUNTER WEIGHT IF THE TENSION IS 32,000 N? WHAT IS THE TWO TENSIONS IF THE ELEVATOR WITHOUT THE PERSON AT $\theta_1 = 32.00°$ AND $\theta_2 = 15.00°$?

$$a_{TOP} = 2.100\ m/s^2 + 9.810\ m/s^2 = -7.710\ m/s^2$$

$$a_{BOTTOM} = 2.100\ m/s^2 + 9.810\ m/s^2 = 11.91\ m/s^2$$

$$T = \frac{2m_1 m_2 g(m_1 + m_2)}{(m_1 + m_2)}$$

$$T(m_1 + m_2) = 2m_1 m_2 g$$

$$Tm_1 + Tm_2 = 2m_1 m_2 g - Tm_2$$

$$\frac{Tm_1}{(2m_1 g - T)} = \frac{m_2(2m_1 g - T)}{(2m_1 g - T)}$$

$$m_2 = \frac{Tm_1}{(2m_1 g - T)} \qquad m_1 = 4{,}070\ kg, \quad T = 32{,}000\ N$$

$$m_2 = \frac{(32{,}000N)(4{,}070\ kg)}{(2(4{,}070kg)(9.810 m/s^2) - 32{,}000N)} = 2{,}721N$$

$$T_1 = \frac{mg\cos\theta_2}{[\cos\theta_2 \sin\theta_1 + \sin\theta_2 \cos\theta_1]} \qquad m = 4{,}000\ kg, \quad \theta_1 = 32.00°, \quad \theta_2 = 15.00°$$

$$= \frac{(4{,}000kg)(9.810 m/s^2)\cos(15.00°)}{[\cos(15.00°)\sin(32.00°) + \sin(15.00°)\cos(32.00°)]}$$

$$= 151{,}839N$$

$$T_2 = \frac{mg}{[\cos\theta_2 \tan\theta_1 + \sin\theta_2]}$$

$$= \frac{(4{,}000kg)(9.810 m/s^2)}{[\cos(15.00°) + \tan(32.00°) + \sin(15.00°)]} = \boxed{45{,}500N}$$