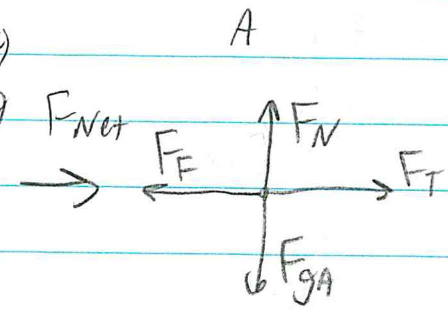
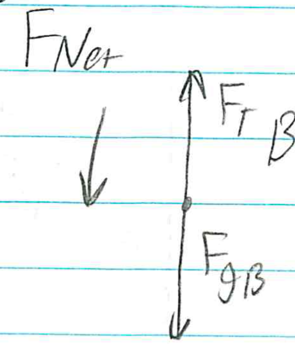
Textbook Problem Solutions March 1/19

36. a) $m_A = 2.3\ kg$

$m_B = 3.5\ kg$

$F_F = 5.4N$





$F_{netAy} = 0$

$F_{netAx} = m_A a$

① $m_A a = F_T - F_f$

$F_{netB} = m_B a$

$m_B a = F_{gB} - F_T$

② $m_B a = m_B g - F_T$

① $F_T - F_f = m_A a$

$+$② $-F_T + m_B g = m_B a$

$0 + m_B g - F_f = m_A a + m_B a$

$a(m_B + m_A) = m_B g - F_f$

$a = \dfrac{m_B g - F_f}{(m_B + m_A)}$

$= \dfrac{(3.5)(9.8) - 5.4}{(3.5 + 2.3)} = 4.98\ m/s^2$

$\boxed{a = 5.0\ m/s^2}$

b) ① $m_A a = F_T - F_f$

$F_T = m_A a + F_f$

$= 2.3 \times 4.98 + 5.4$

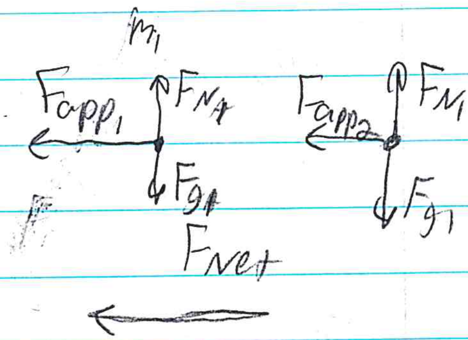
$= 16.854\ N$

$\boxed{F_T = 17\ N}$

40. $m_1 = 1.3\ kg$

$\rightarrow m_2 = 2.4\ kg$

$F_{Net} = 8.6\ N\ [W]$



a) $F_{Net} = ma$

$= (m_1 + m_2)a$

$a = \frac{F_{Net}}{(m_1 + m_2)}$

$= \frac{8.6\ N}{(1.3 + 2.4)} = 2.32\ m/s^2$

$\boxed{a = 2.3\ m/s^2\ [W]}$

b) $F_{Net_1} = m_1 a$

$F_{app_1} = m_1 a$ Could also call

$F_{app_1} = 1.3 \times 2.3$ $F_{app} \rightarrow F_T$.

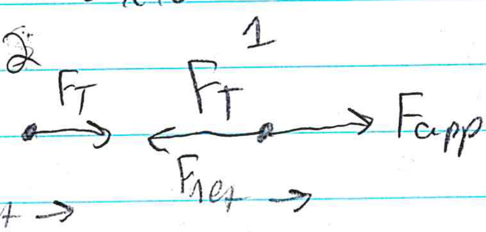
$= 2.99\ N$

$F_{app_1} \doteq 3.0\ N\ [W]$

41. a) $F_{app} = 5.3 \times 10^2\ N$

$m_1 = 11\ kg$

$m_2 = 19\ kg$



1

② $F_{Net_1} = m_1 a$

$m_1 a = F_{app} - F_T$

2/

$F_{Net\,2} = m_2 a$

$m_2 a = F_T \rightarrow a = F_T / m_2$ ①

① → ② $m_1(F_T / m_2) = F_{app} - F_T$

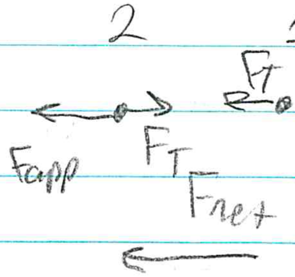
$F_T + \frac{m_1}{m_2} F_T = F_{app}$

$F_T \left(1 + \frac{m_1}{m_2}\right) = F_{app}$

$\rightarrow F_T = F_{app} / \left(1 + \frac{m_1}{m_2}\right)$

$= 5.3 \times 10^2 / (1 + 11/19) = 336\ N$

b)



1/
$F_{net_1} = m_1 a$
$m_1 a = F_T$
① $a = F_T / m_1$

2/
$F_{net_2} = m_2 a$
② $m_2 a = F_{app} - F_T$
①→② $m_2 (F_T / m_1) = F_{app} - F_T$

$F_T + \frac{m_2}{m_1} F_T = F_{app}$

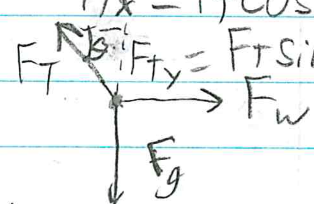
$F_T (1 + \frac{m_2}{m_1}) = F_{app}$

$F_T = F_{app} / (1 + \frac{m_2}{m_1})$

$F_T = 5.3 \times 10^2 / (1 + \frac{19}{11}) = 194\ N$

42. a) $m = 2.5\ kg$
$F_W = 12\ N$

Hard way



$F_{Tx} = F_T \cos\theta$
$F_{Ty} = F_T \sin\theta$

X
$F_{net x} = 0$
$F_W - F_{Tx} = 0$
$F_W = F_{Tx} = F_T \cos\theta$
Square both sides ① $F_W^2 = F_T^2 \cos^2\theta$ ①

Y/ $F_{net y} = 0$
$F_{Ty} - F_g = 0$
$F_{Ty} = F_g$
$F_T \sin\theta = mg$ Square both sides
② $F_T^2 \sin^2\theta = m^2 g^2$

①+② $F_W^2 + m^2 g^2 = F_T^2 \cos^2\theta + F_T^2 \sin^2\theta$
$F_W^2 + m^2 g^2 = F_T^2 (\cos^2\theta + \sin^2\theta)$
$= F_T^2$ ← Pythagorean theorem.

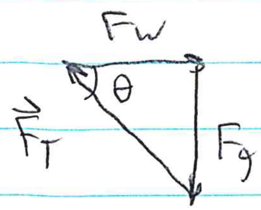
$F_T^2 = F_w^2 + m^2 g^2$

③ $F_T = \sqrt{F_w^2 + m^2 g^2}$

$= \sqrt{12^2 + 2.5^2 (9.8)^2}$

$= 27.2\,N = 27\,N$

The easy way is to recognize that $\vec{F}_w + \vec{F}_g + \vec{F}_T = 0$, which means it forms a closed triangle. F_T is the hypotenuse, so that takes you right to ③



b) $\tan\theta = F_g / F_w$ ← You can also get this equation by doing ② ÷ ①

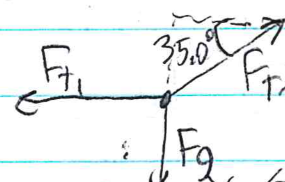
$\theta = \tan^{-1}(F_g/F_w)$

$= \tan^{-1}(2.5 \times 9.8 / 12)$

$\theta = 63.9° = 64°$

43. a) $m = 54\,kg$

$\theta = 35.0°$



$F_{T2x} = F_{T2} \cos 35.0°$

$F_{T2y} = F_{T2} \sin 35.0°$

X

$F_{net_x} = 0$

$F_{T1} - F_{T2x} = 0$

$F_{T1} = F_{T2x} = F_{T2} \cos 35.0°$

$F_{T1} = F_{T2} \cos 35.0°$

$= 922.6 \cos 35.0°$

$= 755.7\,N$

$F_{T1} = 760\,N$

Y

$F_{net_x} = 0$

$F_{T2y} - F_g = 0$

$F_{T2y} = F_{T2} \sin 35.0° = F_g$

$F_{T2} \sin 35.0° = mg$

$F_{T2} = mg / \sin 35.0°$

$= \dfrac{54 \times 9.8}{\sin 35.0°}$

$= 922.6\,N$

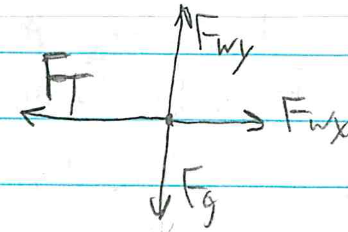
$F_{T2} = 920\,N$

b) This would give the first tension a vertical component. This means the second rope needs to do less to support the performer, and its horizontal component will be lower. The first rope will match this lower horizontal component.

44. $m = 65\ kg$

$v = 25\ m/s$

$F_T = 1.2 \times 10^3\ N\ [S]$



y/

$F_{net_y} = 0$

$F_{wy} - F_g = 0$

$F_{wy} = F_g = mg$

$= 65 \times 9.8$

$\vec{F}_{wy} = 637\ N\ [Up]$

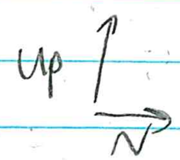
x/ $a = 0$

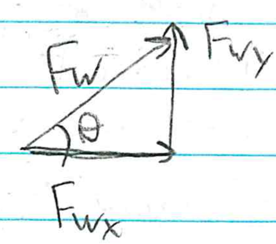
$F_{net_x} = 0$

$F_{wx} - F_T = 0$

$F_{wx} = F_T$

$\vec{F}_{wx} = 1.2 \times 10^3\ N\ [N]$





$F_w^2 = F_{wx}^2 + F_{wy}^2$

$F_w = \sqrt{F_{wx}^2 + F_{wy}^2}$

$= \sqrt{(1.2 \times 10^3)^2 + 637^2}$

$= 1359\ N$

$= 1400\ N$

$\tan\theta = F_{wy}/F_{wx}$

$\theta = \tan^{-1}(F_{wy}/F_{wx})$

$= \tan^{-1}(637/1.2 \times 10^3)$

$= 27.96°$

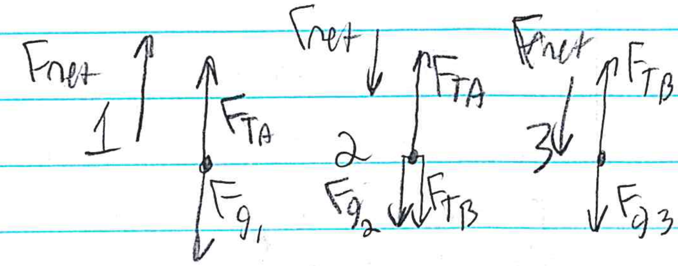
$= 28°$

$\vec{F}_w = 1400\ N\ [N\ 28°\ Up]$

47. $m_1 = 6.0\,kg$

$m_2 = 4.0\,kg$

$m_3 = 3.0\,kg$



1/ $F_{net_1} = m_1 a$

$m_1 a = F_{T_A} - F_{g_1}$

$m_1 a = F_{T_A} - m_1 g$

$F_{T_A} = m_1 a + m_1 g$

$= m_1(a+g)$

(1)

2/ $F_{net_2} = m_2 a$

$m_2 a = F_{T_B} + m_2 g - F_{T_A}$

(3)

3/ $F_{net_3} = m_3 a$

$m_3 a = m_3 g - F_{T_B}$

$F_{T_B} = m_3 g - m_3 a$

$F_{T_B} = m_3(g-a)$

(2)

(1) and (2) → (3)

$m_2 a = m_3(g-a) + m_2 g - m_1(a+g)$

$= m_3 g - m_3 a + m_2 g - m_1 a - m_1 g$

$m_1 a + m_2 a + m_3 a = m_3 g + m_2 g - m_1 g$

$a(m_1 + m_2 + m_3) = g(m_3 + m_2 - m_1)$

$a = \frac{g(m_3 + m_2 - m_1)}{(m_1 + m_2 + m_3)}$

$= 9.8\left(\frac{3+4-6}{6+4+3}\right)$

$= 0.754\,m/s^2$

$a = 0.75\,m/s^2$

(1) $F_{TA} = m_1(a+g)$

$= 6.0(0.754 + 9.8)$

$= 63.3\,N$

$F_{TA} = 63\,N$

(2) $F_{TB} = m_3(g-a)$

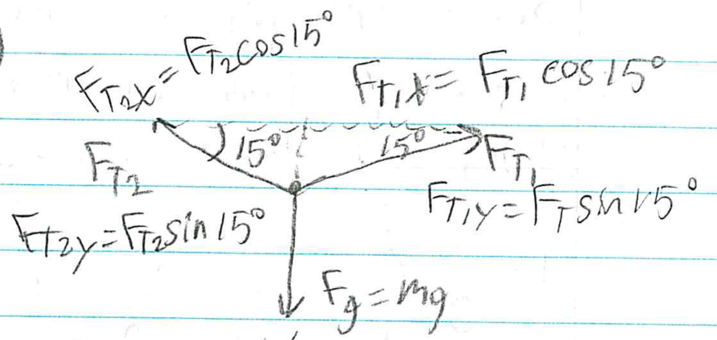
$= 3(9.8 - 0.754)$

$= 27.1\,N$

$F_{TB} = 27\,N$

48. $m = 60.0\ kg$

$\theta = 15°$



Y/ $F_{net\,y} = 0$

$F_{T1y} + F_{T2y} - mg = 0$

$F_{T1y} + F_{T1y} - mg = 0$

$2F_{T1y} - mg = 0$

$F_{T1y} = \frac{mg}{2}$

$F_{T1} \sin 15° = \frac{mg}{2}$

$F_T = \frac{mg}{2 \sin 15°} = \frac{60 \times 9.8}{2 \sin 15°} = 1136\ N$

$F_T = 1100\ N$

X/ $F_{net\,x} = 0$

$F_{T1x} - F_{T2x} = 0$

$F_{T1x} = F_{T2x}$

$F_{T1} \cos 15° = F_{T2} \cos 15°$

$F_{T1} = F_{T2}$

$\therefore F_{T1y} = F_{T2y}$

68. a) The person has one tension pulling the seat up, then another pulling their hand up, so they have to do half the work.

b)

$F_{net} = 0$

$2F_T - mg = 0$

$F_T = mg/2$

$= \frac{59.2 \times 9.8}{2}$

$F_T = 290N$

F_T is the force the rope exerts on the person, but Newton's third law tells us the force the person exerts is equal and opposite, so also 290N.

c) This assumes the person exerts the same force at all time.