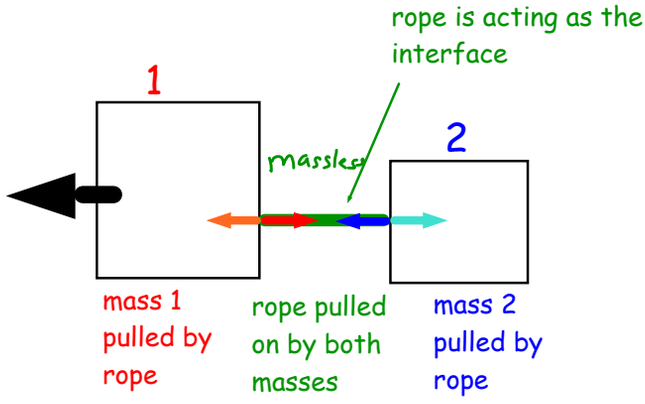
More Connected Systems



system: Boxes connected by rope

Forces Exerted on Box 1

Symbol	Word Description	Classification
F_{g1}	Gravity pulls mass 1 down	Ext
F_{N1}	Ground pushes mass 1 up	Ext
F_A	Hand pulls mass 1 to left	Ext
F_{TR1}	Tension pulls mass 1 to the right	Int

Forces Exerted on Rope

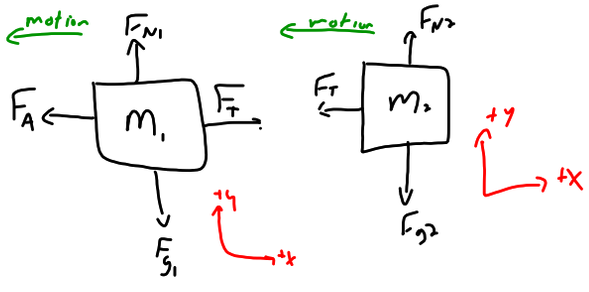
Symbol	Word Description	Classification
F_{T2R}	Mass 2 pulls rope to the right	Int
F_{T1L}	Mass 1 pulls rope to the left	Int

$F_{TL2} = F_{T2R} = F_{T1L} = F_{TR1} = F_T$

Forces Exerted on Box 2

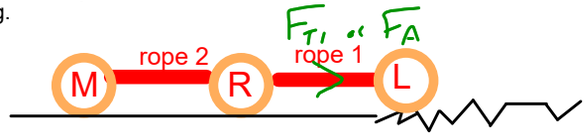
Symbol	Word Description	Classification
F_{g2}	Gravity pulls mass 2 down	Ext
F_{N2}	Ground pushes mass 2 up	Ext
F_{TL2}	Tension pulls mass 2 to the left	Int

Draw free body diagram for the system below. Label all forces clearly.



Pulling Connected Systems

Ex. 1: Roxy and Moxy are standing in a line connected by a rope. They are standing on an ice surface having negligible friction. Lou, standing off ice, starts to pull Roxy with a force of 360. N [E]. Assume the mass of each girl is 60. kg.

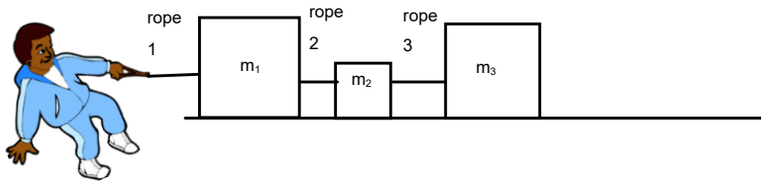


a) What is the acceleration of the girls? 3.00 m/s²

b) What is Net force acting on Roxy? 180 N

c) What is the tension in rope 2 pulling on Moxy? 180 N

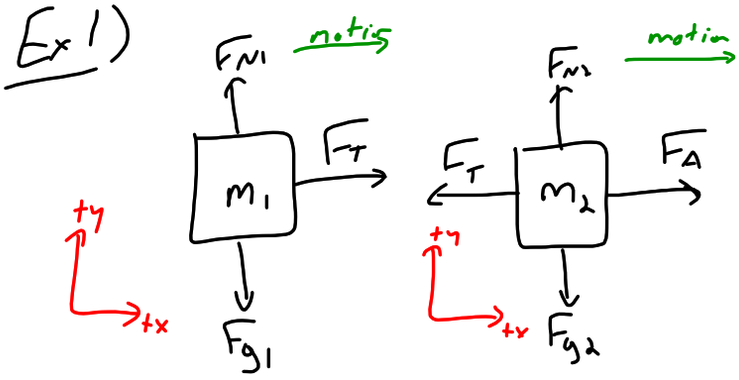
Ex. 2: Masses one, two, and three are 4.0 kg, 1.0 kg, and 3.0 kg, respectively. They are connected to each other by rope. The student is pulling westward on rope 1 to give the system an acceleration of 0.300 m/s^2.



What is the force of Tension in all 3 ropes if the coefficient of kinetic friction for each block and the floor is 0.200?

Do Practice Problems 18-20 on page 182

Ex 1)



$m_1 = 60.\ kg$ $\quad \vec{F}_A = 360.\ N\ [E]$

$m_2 = 60.\ kg$ $\quad \vec{a}_y = 0\ m/s^2$

$m_{sys} = m_1 + m_2 = 120.\ kg$ $\quad \vec{g} = 9.81\ m/s^2\ [down]$

$\vec{a}_{sys} = ?$

a) $F_{Net,sys} = F_A - F_T + F_T = m_{sys}\, a_{sys}$

$F_A = m_{sys}\, a_{sys}$

$a_{sys} = \frac{F_A}{m_{sys}} = \frac{360.\ N}{120.\ kg} = 3.00\ m/s^2$

$\vec{a}_{sys} = 3.00\ m/s^2\ [E]$

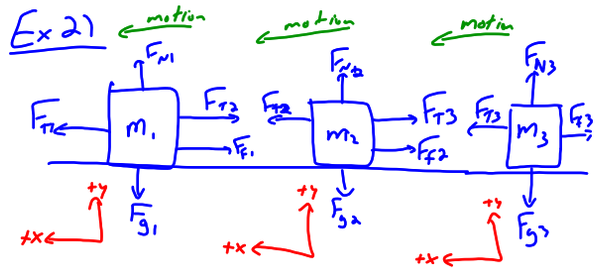
b) $F_{Net,2} = m_2 a_2 = (60.\ kg)(3.00\ m/s^2) = 180\ N$

$\vec{F}_{Net,2} = 180\ N\ [E]$

c) $F_{Net,1} = F_{T2} = m_1 a_1 = (60.\ kg)(3.00\ m/s^2)$

$= 180\ N$

Ex 21



$m_1 = 4.0\ kg$ $\quad \vec{a}_y = 0\ m/s^2$ (each)

$m_2 = 1.0\ kg$ $\quad \vec{g} = 9.81\ m/s^2$ [down]

$m_3 = 3.0\ kg$ $\quad \mu_K = 0.200$

$m_{sys} = m_1 + m_2 + m_3 = 8.0\ kg$ $\quad \vec{a}_{sys} = 0.300\ m/s^2$ [W]

a) $F_{Net,sys} = F_{T1} - F_{T2} - F_{f1} + F_{T2} - F_{f2} - F_{T3} + F_{T3} - F_{f3} = m_{sys} a_{sys}$

$\therefore F_{T1} - F_{f1} - F_{f2} - F_{f3} = m_{sys} a_{sys}$

$F_{Net,y1} = F_{N1} - F_{g1} = m a_{y1} = 0$ N

$F_{N1} = F_{g1} \rightarrow F_{N2} = F_{g2}$ vertical same for all 3

$F_{N3} = F_{g2}$

$F_{Net,sys} = F_{T1} - F_{f1} - F_{f2} - F_{f3} = m_{sys} a_{sys}$

$F_{T1} - \mu_K F_{N1} - \mu_K F_{N2} - \mu_K F_{N3} = m_{sys} a_{sys}$

$F_{T1} - \mu_K (F_{g1} + F_{g2} + F_{g3}) = m_{sys} a_{sys}$

$F_{T1} - \mu_K (m_1 g + m_2 g + m_3 g) = m_{sys} a_{sys}$

$F_{T1} - \mu_K g (m_1 + m_2 + m_3) = m_{sys} a_{sys}$

$F_{T1} - \mu_K m_{sys} g = m_{sys} a_{sys} + \mu_K m_{sys} g$

$F_{T1} = m_{sys} (a_{sys} + \mu_K g)$

$= (8.0\ kg)(0.300\ m/s^2 + (0.200)(9.81\ m/s^2))$

$F_{T1} = 18.096\ N = \boxed{18\ N}$

$$F_{Net,1} = F_{T1} - F_{T2} - F_{f1} = m_1 a_1$$

$$F_{T2} = F_{T1} - F_{f1} - m_1 a_1$$

$$= F_{T1} - \mu_k m_1 g - m_1 a_1$$

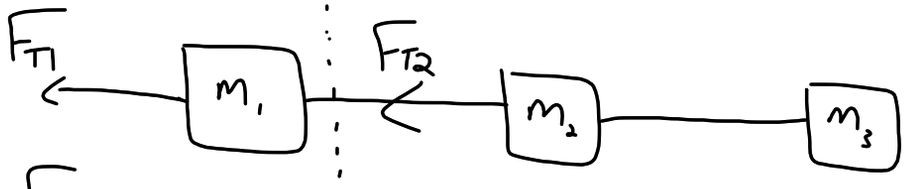
$$= F_{T1} - m_1(\mu_k g + a_1)$$

$$= 18.096\,N - (40\,kg)\left((0.200)(9.81\,m/s^2) + 0.300\,m/s^2\right)$$

$$= 9.048\,N = \boxed{9\,N}$$

$$F_{T3} = F_{T2} - m_2(\mu_k g + a_2)$$

$$= 6.786\,N = \boxed{7\,N}$$



F_{T1} pulls all 3 or 100% of mass

F_{T2} pull last 2 or $\frac{m_2+m_3}{m_{sys}} = \frac{4\,kg}{8\,kg} = 0.5$ or 50%

F_{T3} pull $\frac{m_3}{m_{sys}} = \frac{3\,kg}{8\,kg} = 0.375$ or 37.5%