Physics 200
Newton's Laws + Trig.
Bodies on Inclines

1

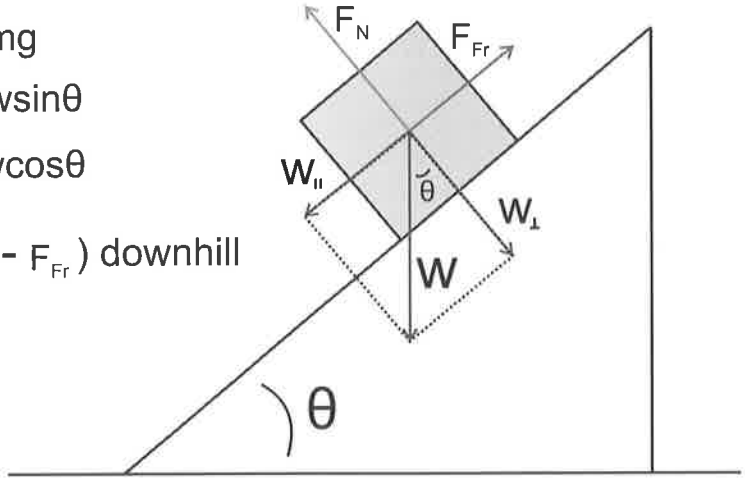
Name: _____

$w = mg$

$w_{\parallel} = w\sin\theta$

$w_{\perp} = w\cos\theta$

$\Sigma F = (w_{\parallel} - F_{Fr})$ downhill



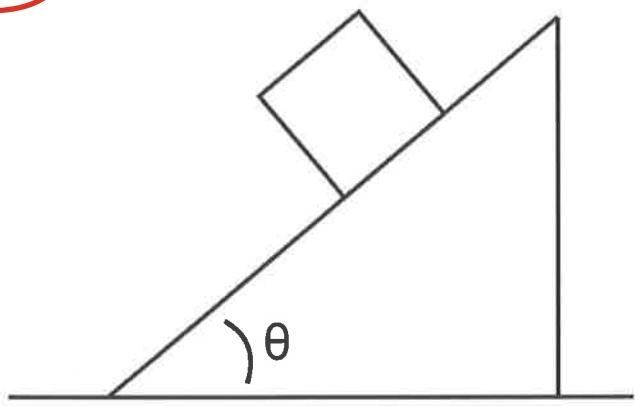
- The perpendicular component of weight determines the normal force and, therefore, friction.
- The parallel component of weight contributes to acceleration.
- Unless friction is as strong as the parallel weight component, friction and weight are the only two non-canceling forces contributing to the net force.

Practice Problem: Fill in the remaining cells in the table below.

Item	Direction (When applicable)	Magnitude
coefficient of friction	NA	0.4
θ (degrees)	NA	30
Mass of object (kg)	NA	2
Weight of object (N)	Downward	19.6
Perpendicular Weight Component (N)	Perpendicularly toward incline	16.97409791
Parallel Weight Component (N)	Parallel to incline, downhill	9.8
Normal force (N)	Perpendicularly away from incline	16.97409791
Force of Friction (N)	Parallel to incline, uphill	6.789639166
Net force on object (N)	Parallel to incline, downhill	3.010360834
Acceleration (m/s^2)	Parallel to incline, downhill	1.505180417

2

1a. The figure to the right shows a block on an incline. Draw and label the forces acting on the block. Resolve weight into perpendicular and parallel components, relative to the surface.

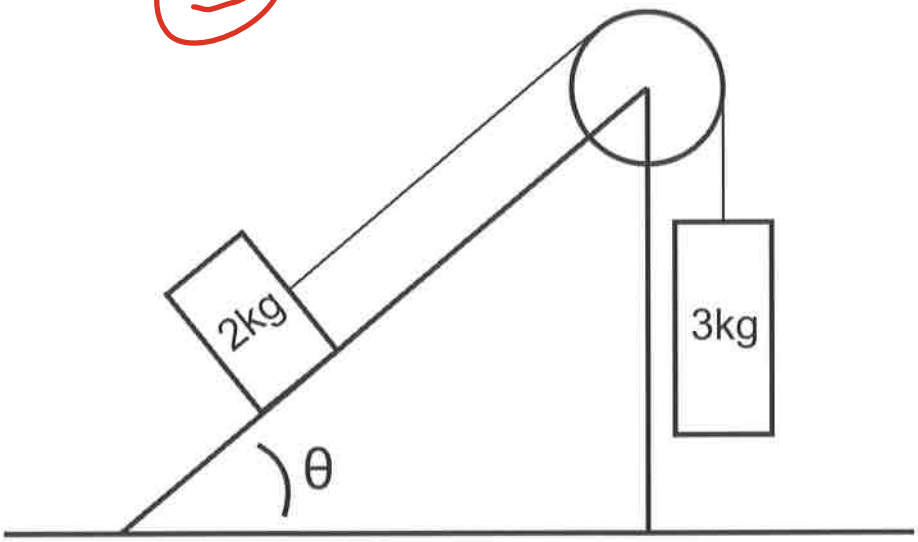


1b. Fill in the table below for the block on the ramp.

Item	Direction (When applicable)	Magnitude
coefficient of friction	NA	.6
θ (degrees)	NA	60
Mass of object (kg)	NA	2
Weight of object (N)	Downward	19.6
Perpendicular Weight Component (N)	Perpendicularly toward incline	9.8
Parallel Weight Component (N)	Parallel to incline, downhill	16.97409791
Normal force (N)	Perpendicularly away from incline	9.8
Force of Friction (N)	Parallel to incline, uphill	5.88
Net force on object (N)	Parallel to incline, downhill	11.09409791
Acceleration (m/s^2)	Parallel to incline, downhill	5.547048957

3

2. Fill out the table for the 2kg block, below. Then find the masses' accelerations and the tension in the string.



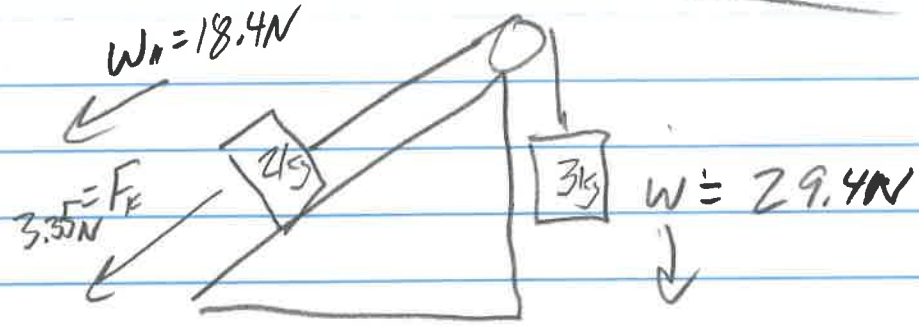
a = **1.53m/s^2 up the ramp**

Tension = **24.8N**

Item	Direction (When applicable)	Magnitude
coefficient of friction	NA	**0.5**
θ (degrees)	NA	**70**
Mass of object (kg)	NA	**2**
Weight of object (N)	Downward	19.6
Perpendicular Weight Component (N)	Perpendicularly toward incline	6.703594809
Parallel Weight Component (N)	Parallel to incline, downhill	18.41797537
Normal force (N)	Perpendicularly away from incline	6.703594809
Force of Friction (N)	Parallel to incline, **downhill**	3.351797405

Bodies on Inclines #2 & 3 accel. & tension

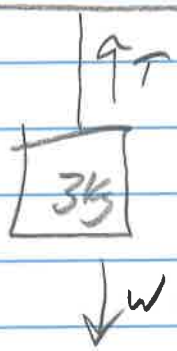
2.



$$\Sigma F = 29.4N - 18.4N - 3.35N$$
$$= 7.65N \searrow$$

$$7.65N = (5kg)\,a \Rightarrow a = 1.53\,m/s^2 \searrow$$

$$\Sigma F = m\,a$$

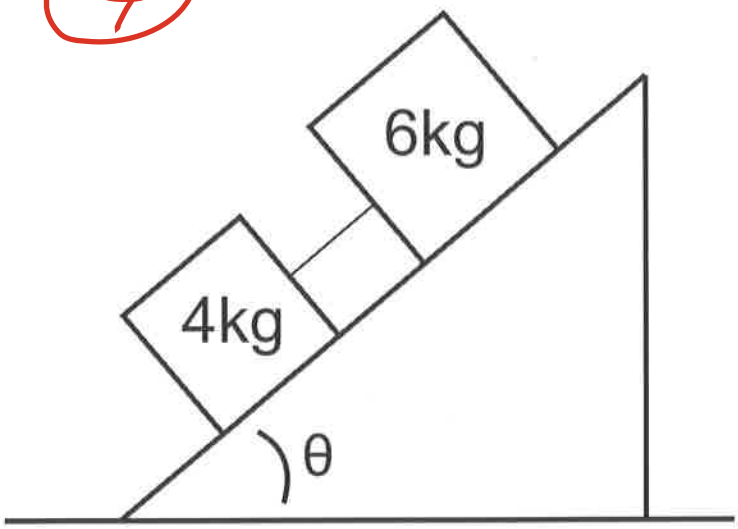


$$T - 29.4N = 3kg\,(-1.53\,m/s^2)$$

$$T = 24.8N$$

4

3. In the diagram, the 6kg block has a μ_k of 0.5, but the 4kg block is frictionless. Fill in the tables. Then find the accelerations of the blocks and the tension in the string.



a = **6.0 m/s^2 downhill**

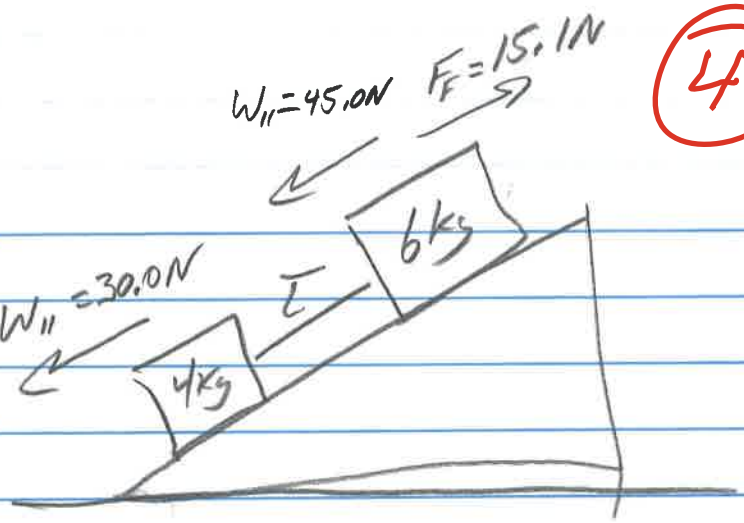
Tension = **6.0N**

Item	Direction (When applicable)	Magnitude
coefficient of friction	NA	**0**
θ (degrees)	NA	**50**
Mass of object (kg)	NA	**4**
Weight of object (N)	Downward	39.2
Perpendicular Weight Component (N)	Perpendicularly toward incline	25.1972743
Parallel Weight Component (N)	Parallel to incline, downhill	30.02894217
Normal force (N)	Perpendicularly away from incline	25.1972743
Force of Friction (N)	NA	0

Item	Direction (When applicable)	Magnitude
coefficient of friction	NA	**0.4**
θ (degrees)	NA	**50**
Mass of object (kg)	NA	**6**
Weight of object (N)	Downward	58.8
Perpendicular Weight Component (N)	Perpendicularly toward incline	37.79591145
Parallel Weight Component (N)	Parallel to incline, downhill	45.04341326
Normal force (N)	Perpendicularly away from incline	37.79591145
Force of Friction (N)	Parallel to incline, uphill	15.11836458

4

3.

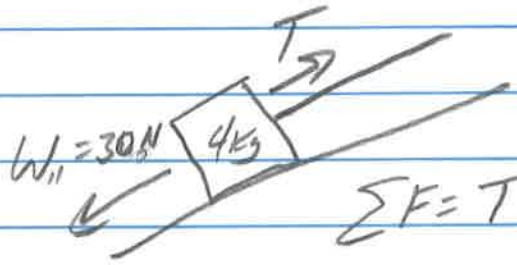


$$\Sigma F = 15.1N - 45.0N - 30.0N = -59.9N$$

$$-59.9N = ma = 10kg(a)$$

$$a = -5.99\ m/s^2$$

$a = 5.99\ m/s^2$ downhill

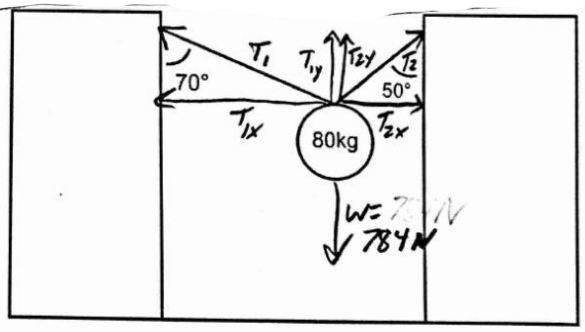


$$\Sigma F = T - 30N = 4kg(-5.99\ m/s^2)$$

$$T = 6.04N$$

5

1. The 80kg mass is in static equilibrium. Find the tensions in the two segments of rope.



$\Sigma F_x = 0 = T_{2x} - T_{1x} \Rightarrow T_{1x} = T_{2x}$

$\Sigma F_y = 0 = T_{1y} + T_{2y} - 784N$

$T_{1x} = \sin 70°(T_1)$ $T_{2x} = \sin 50°(T_2)$

0.94 0.766

$0.94 T_1 = 0.766 T_2$

$T_1 = 0.815 T_2$

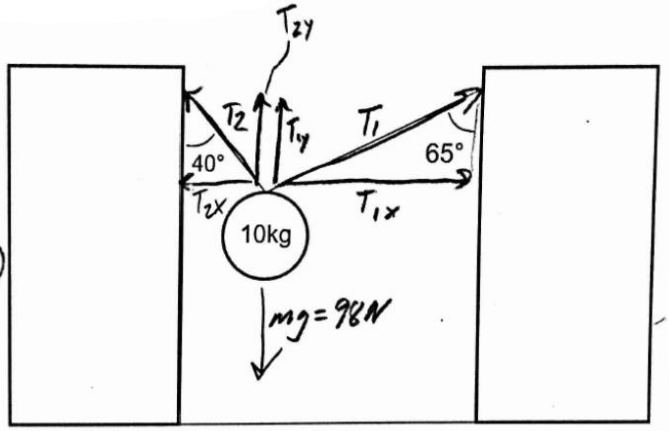
$\cos 70°(T_1) + \cos 50°(T_2) - 784N = 0$

$0.342(0.815 T_2) + 0.643(T_2) - 784N = 0$

$0.279 T_2 + 0.643 T_2 = 784N$

$T_2 = 850N$ $T_1 = 693N$

2. The 10kg mass is in static equilibrium. Find the tensions in the two segments of rope.



$\Sigma F_y = 0 = T_{1y} + T_{2y} - 98N$

$\Sigma F_x = 0 = T_{1x} - T_{2x} \Rightarrow T_{1x} = T_{2x}$

$\sin 65°(T_1) = \sin 40°(T_2)$

$0.906 T_1 = 0.643 T_2$

$T_1 = 0.71 T_2$

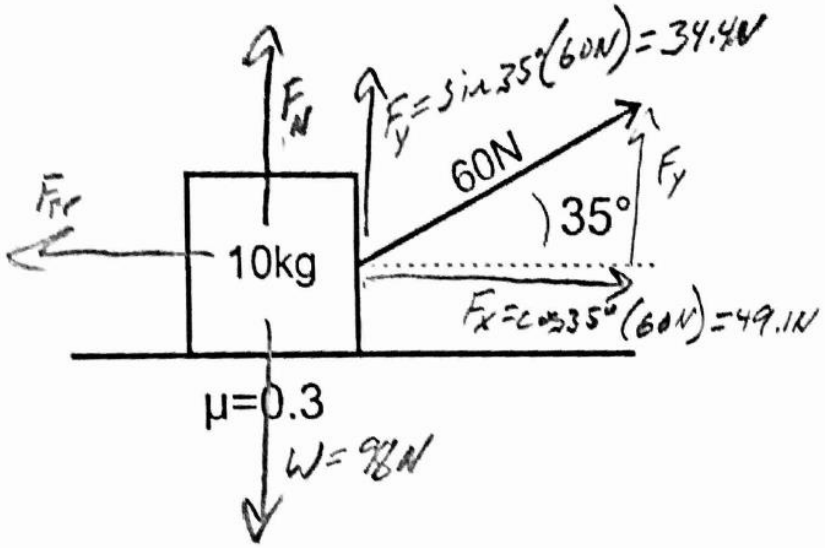
$0 = \cos 65° T_1 + \cos 40° T_2 - 98N$

$0 = 0.423 T_1 + 0.766 T_2 - 98N = 0.423(0.71 T_2) + 0.766 T_2 - 98N$

$0 = 0.766 T_2 + 0.3 T_2 - 98N$

$T_2 = 91.5N \Rightarrow T_1 = 0.71 T_2 = 65N$

3. Find the acceleration of the 10 kg mass.



$\Sigma F_y = F_y + F_N - w = 0$

$0 = 34.4N + F_N - 98N$

$F_N = 63.6N$

$\Sigma F_x = F_x - F_{fr}$

$= 49.1N - \mu F_N$

$= 49.1N - (0.3)(63.6N)$

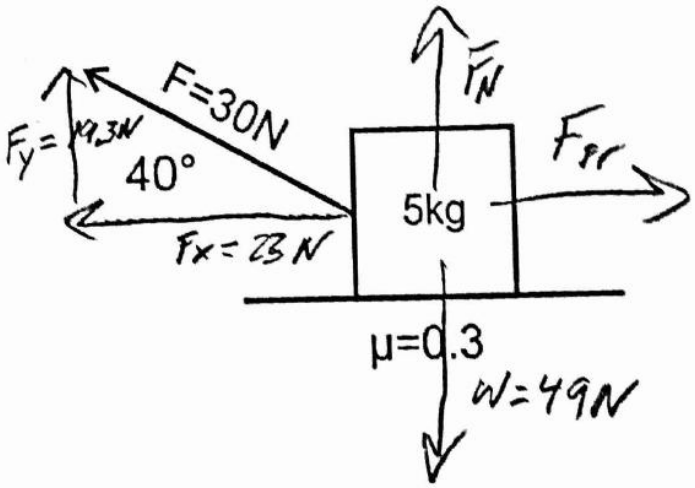
$\Sigma F_x = 29.9N$

$\Sigma F_x = m a_x$

$29.9N = 10kg\,(a_x)$

$a_x = 2.99\ m/s^2$

4. Find the acceleration of the 8kg mass.



$\Sigma F_y = F_y + F_N - w = 0$

$= 19.3N + F_N - 49N = 0$

$F_N = 29.7N$

$\Sigma F_x = F_{fr} - F_x$

$= \mu F_N - F_x$

$= 0.3(29.7N) - 23N$

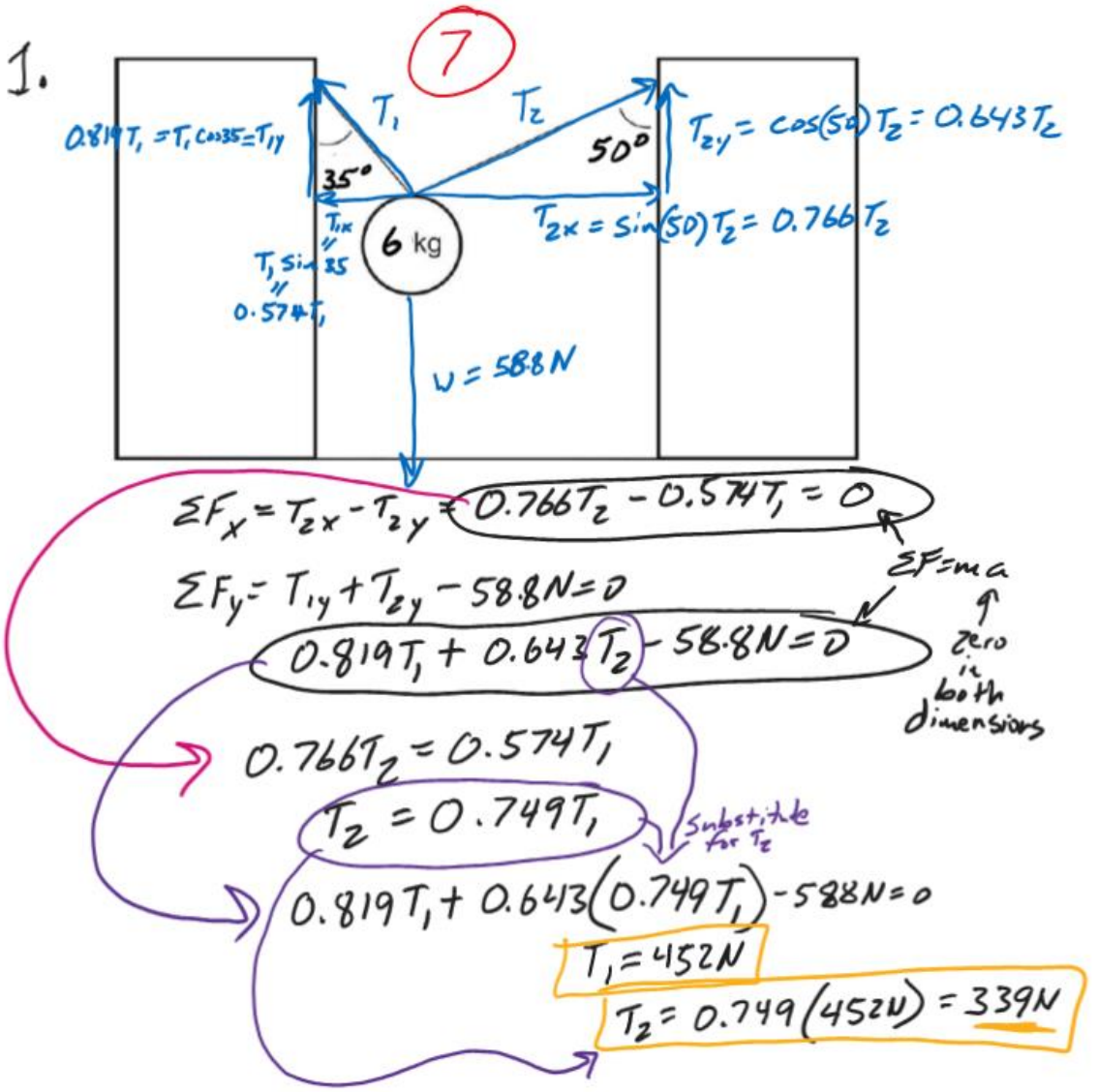
$= -14.1N$

$\Sigma F_x = m a_x$

$-14.1N = 5kg\,(a_x)$

$a_x = -2.82\ m/s^2$

1.



$\Sigma F_x = T_{2x} - T_{2y} = 0.766T_2 - 0.574T_1 = 0$

$\Sigma F_y = T_{1y} + T_{2y} - 58.8N = 0$

$0.819T_1 + 0.643T_2 - 58.8N = 0$

$\Sigma F = ma$ ↑ zero in both dimensions

$0.766T_2 = 0.574T_1$

$T_2 = 0.749T_1$ Substitute for T_2

$0.819T_1 + 0.643(0.749T_1) - 588N = 0$

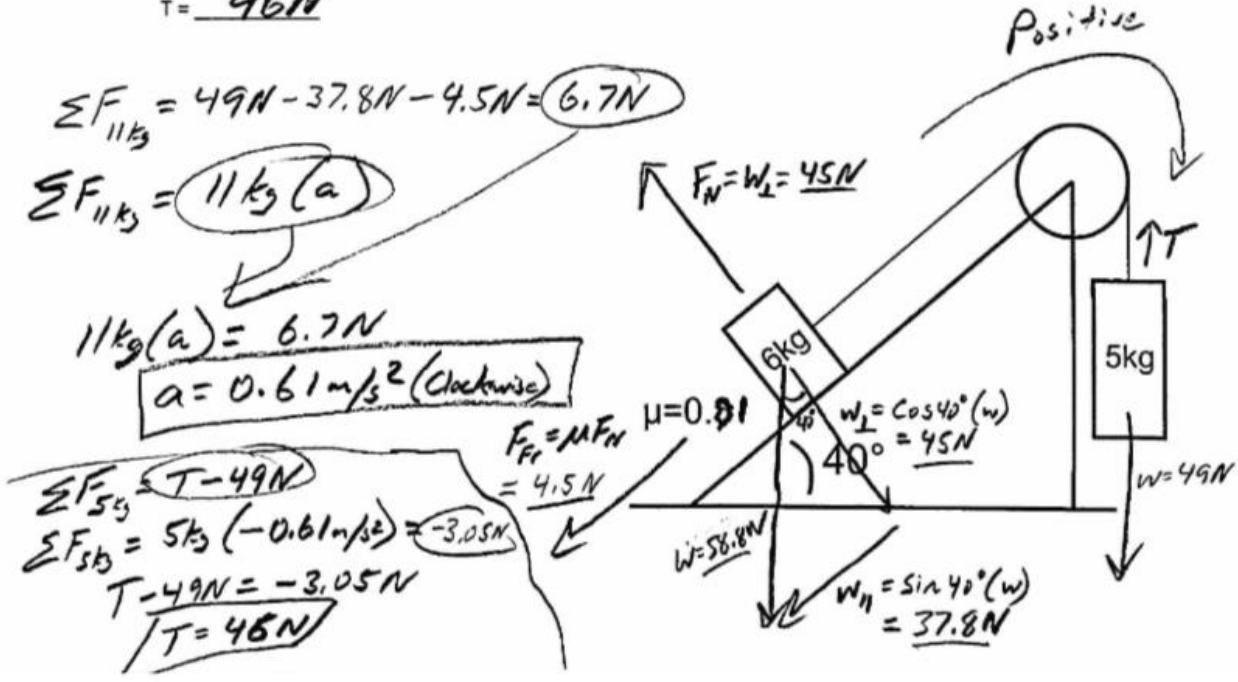
$T_1 = 452N$

$T_2 = 0.749(452N) = 339N$

2. Find the acceleration of the masses and the tension in the string.

a = 0.61 m/s² CW

T = 46N



$\Sigma F_{11kg} = 49N - 37.8N - 4.5N = 6.7N$

$\Sigma F_{11kg} = 11kg(a)$

$11kg(a) = 6.7N$

$a = 0.61 m/s^2$ (clockwise)

$F_{Fr} = \mu F_N = 4.5N$

$\Sigma F_{5kg} = T - 49N$

$\Sigma F_{5kg} = 5kg(-0.61 m/s^2) = -3.05N$

$T - 49N = -3.05N$

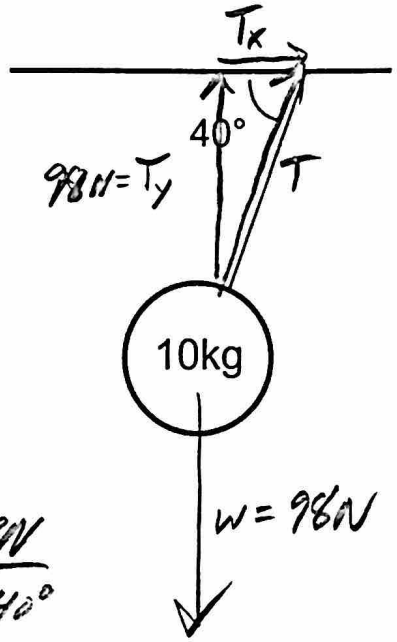
$T = 46N$

8

3. The mass is suspended from the ceiling of a moving vehicle. The angle shown is constant. Find the acceleration of the mass and the tension in the string.

a = 11.7 m/s², rightward

T = 152 N



$\Sigma F_y = 0 = T_y - 98N \Rightarrow T_y = 98$

$\Sigma F_x = T_x$ $\quad \tan 40° = \frac{98N}{T_x} \Rightarrow T_x = \frac{98N}{\tan 40°}$

$T_x = 117N$

$\Sigma F_x = 10kg(a)$

$10kg(a) = 117N$

$a = 11.7 m/s^2$

$T = \sqrt{98^2 + 117^2}$

$T = 152N$

4. Find the acceleration of the 8kg mass. ***To make this problem more interesting, use μ=0.2, instead***

$\Sigma F_y = 0 = F_N + 19.3N - 78.4N \Rightarrow F_N = 58.7N$

$\Sigma F_x = 11.8N - 23N = -11.2N$

$\Sigma F_x = 8kg(a)$

$8kg(a) = -11.2N$

$a = -1.4 m/s^2$

$a = 1.4 m/s^2$ leftward