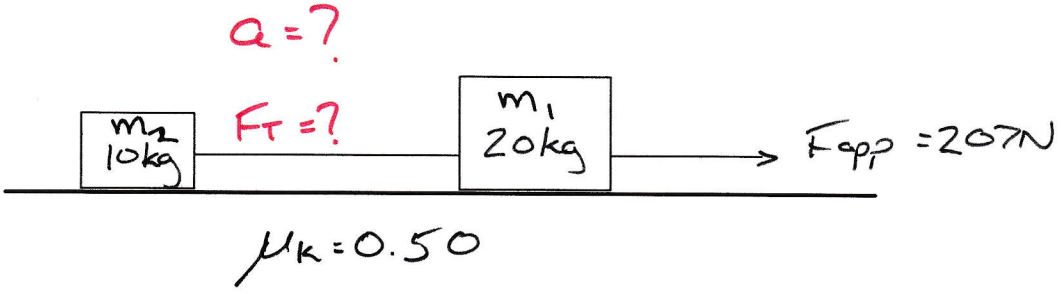
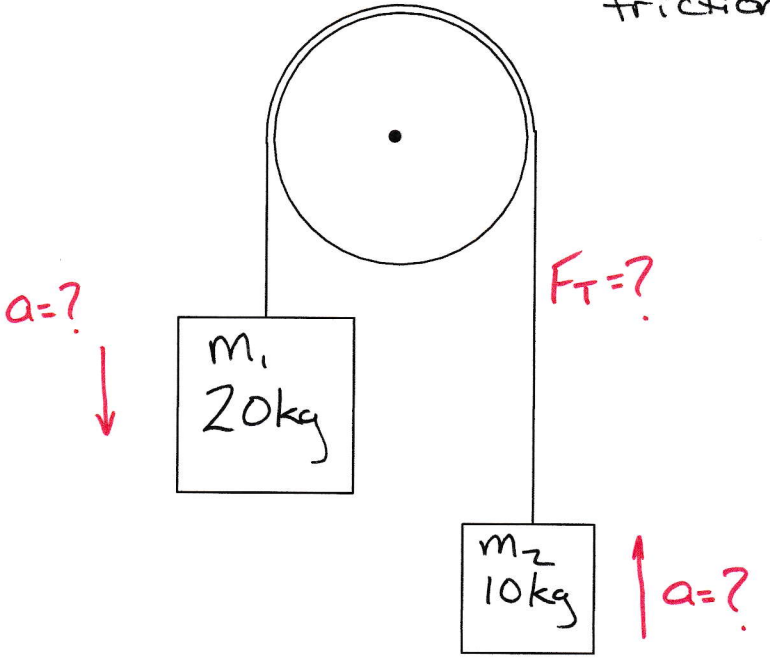
Solving Problems Involving More Than One Object

Example #1: Two objects (10 kg and 20 kg) are tied together and pulled to the right with an applied force of 207N as shown below. What is the tension in the string between the objects and the overall acceleration of the two objects?



Example #2: Two objects (10 kg and 20 kg) are connected to each end of a string which is looped around a pulley as shown below. The masses are released and allowed to move. What is the tension in the string and the acceleration of each object?

mass pulley = ϕ
friction on pulley = ϕ



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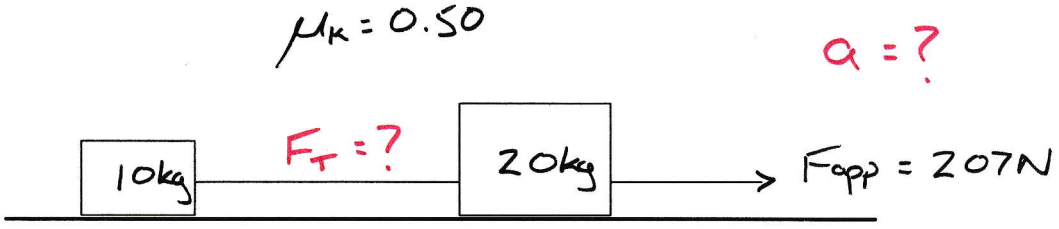
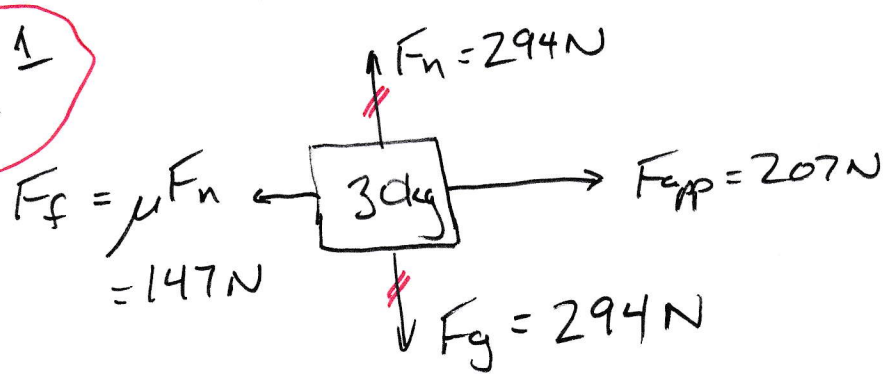


Treat as 1 object

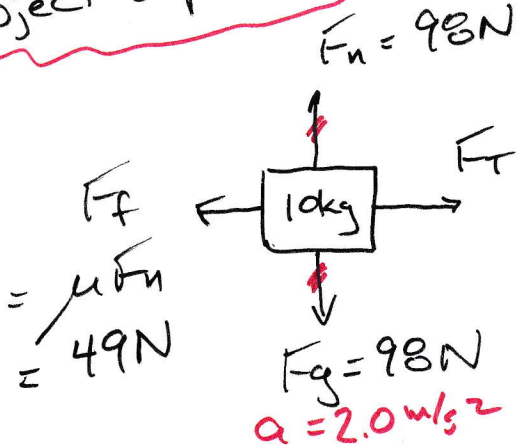


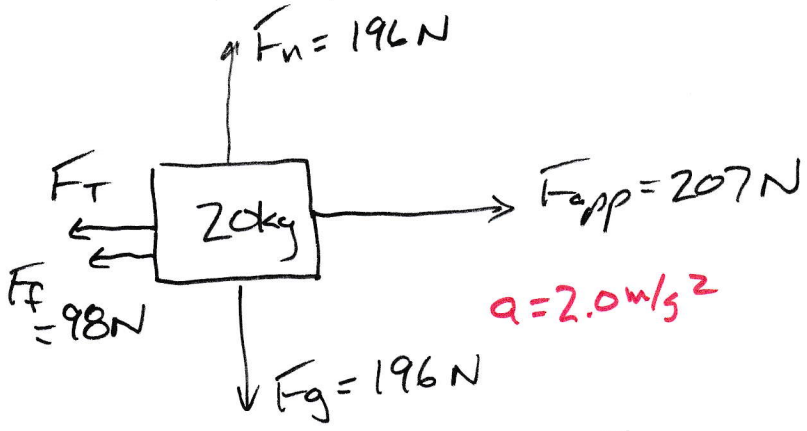
$F_{net} = ma \rightarrow F_{app} - F_f = ma$

$60N = 30a$

$a = 2.0 m/s^2$

Analyze each object separately





$F_{net} = F_T - F_f$

$ma = F_T - 49N$

$(10)(2) = F_T - 49$

$F_T = 69N$

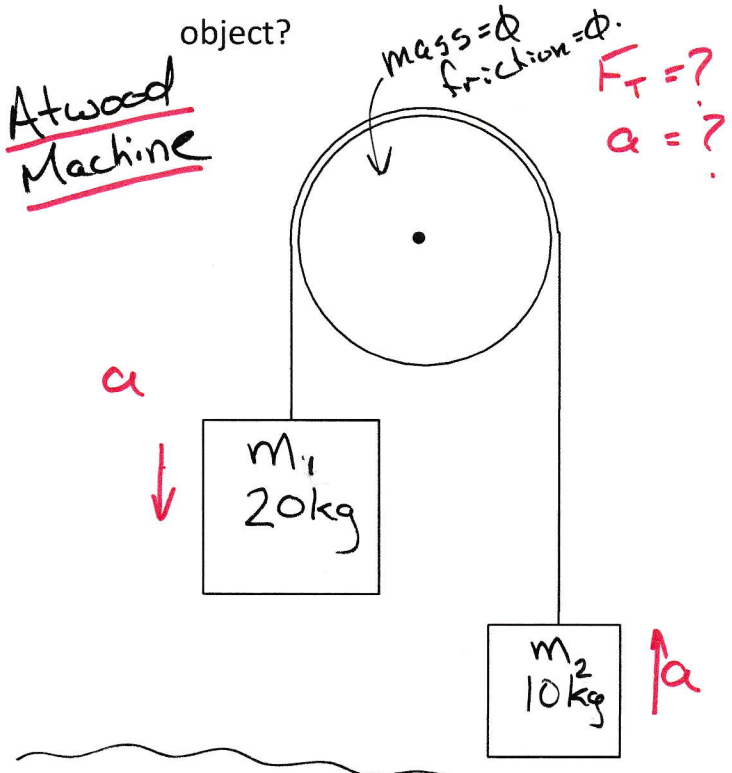
$F_{net} = F_{app} - F_T - F_f$

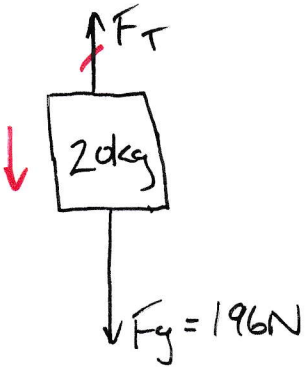
$(20)(2) = 207 - F_T - 98$

$F_T = 69N$

Example #2: Two objects (10 kg and 20 kg) are connected to each end of a string which is looped around a pulley as shown below. The masses are released and allowed to move. What is the tension in the string and the acceleration of each object?

Atwood Machine

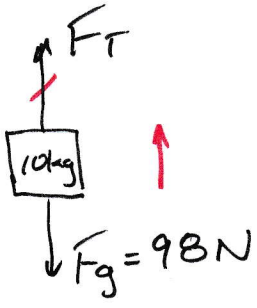




$F_{net} = F_g - F_T$

$m_1 a = m_1 g - F_T$

① $20a = 196 - F_T$



$F_{net} = F_T - F_g$

$m_2 a = F_T - m_2 g$

② $10a = F_T - 98$

① + ②

$20a + 10a = 196 - F_T + F_T - 98$

$30a = 98$

$a = 3.3\ m/s^2\ (3.266...)$

③ $10(3.2666) = F_T - 98$

$F_T = 130N\ (130.66..)$

Generic

① $m_1 a = m_1 g - F_T$

② $m_2 a = F_T - m_2 g$

① + ②

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

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

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