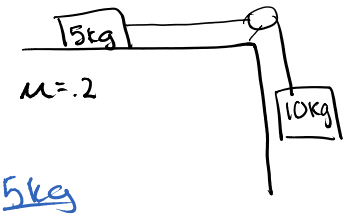
Connected Objects

Monday, October 21, 2013 7:38 AM

Suppose a 5 kg box rests on a table. It is connected to a 10 kg hanging off the table by a pulley. The coefficient of friction between the box and the table is .2. What is the acceleration of the two objects?




5kg

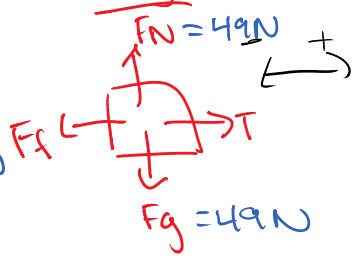
$F_g = mg = 5 \cdot 9.8 = 49N$

$F_N = F_g = 49N$

$F_f = \mu F_N = 0.2 \cdot 49 = 9.8N$

FBD

5kg



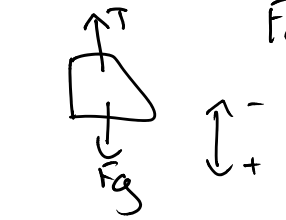

$F_{net} = ma$

$T - F_f = ma$

$T - 9.8 = 5a$

$T = 5a + 9.8$

10kg




$F_g = mg = 10 \cdot 9.8 = 98N$

$F_{net} = ma$

$F_g - T = ma$

$98 - T = 10a$

$98 - (5a + 9.8) = 10a$

$98 - 5a - 9.8 = 10a$

$88.2 - 5a = 10a$

$88.2 = 15a$

$98 - T = 10a$

$+(T - 9.8 = 5a)$

$98 - \cancel{T} + \cancel{T} - 9.8 = 15a$

$88.2 = 15a$

$a = 5.88 m/s^2$

$T = 5(5.88) + 9.8$

$= 39.2N$

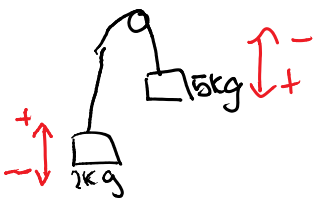
Reasonableness of Answer

expect a between $0 + 9.8 m/s^2$

expect T between $F_f(9.8)$ & $F_g(98)$

Attwood Machine example

A 2 kg mass is attached via a pulley to a 5 kg mass. Both hang free in the air. What is the acceleration of the two masses?




2 FBD

2kg


$F_g = mg = 2 \cdot 9.8 = 19.6N$

$F_{net} = ma$

$T - F_g = ma$

$T - 19.6 = 2a$

$T = 2a + 19.6$

5kg


$F_g = mg = 5 \cdot 9.8 = 49N$

$F_{net} = ma$

$F_g - T = ma$

$49 - T = 5a$

$49 - (2a + 19.6) = 5a$

$49 - 2a - 19.6 = 5a$

$29.4 = 7a$

$a = 4.2 m/s^2$

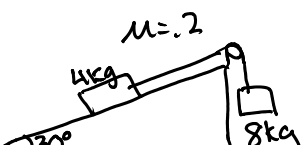
$T = 2a + 19.6$

$= 2(4.2) + 19.6$

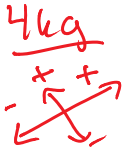
$= 28N$

Solve the following diagram

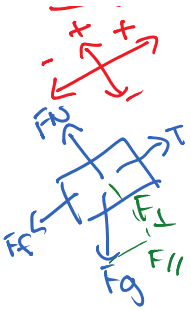
A 4 kg mass is attached via a pulley to an 8 kg mass. The 4 kg mass rests on a 30 degree ramp with a coefficient of friction of .2, while the 8 kg mass hangs in the air. What is the acceleration of the two masses?

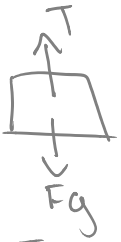



4kg




8kg


$F_g = mg = 4 \cdot 9.8 = 39.2\,N$

$F_{\parallel} = F_g \sin\theta = 39.2 \sin 30 = 19.6\,N$

$F_{\perp} = F_g \cos\theta = 39.2 \cos 30 = 33.95\,N$

$F_N = F_{\perp} = 33.95\,N$

$F_f = \mu F_N = .2 \cdot 33.95 = 6.79\,N$

$F_{net\parallel} = ma_{\parallel}$

$T - F_f - F_{\parallel} = ma$

$T - 6.79 - 19.6 = 4a$

$T - 26.4 = 4a$

$T = 4a + 26.4$

$F_g = mg = 8 \cdot 9.8 = 78.4\,N$

$F_{net} = ma$

$F_g - T = ma$

$78.4 - T = 8a$

$78.4 - (4a + 26.4) = 8a$

$78.4 - 4a - 26.4 = 8a$

$52.0 = 12a$

$4.3\,m/s^2 = a$

$T = 4(4.3) + 26.4$

$= 17.2 + 26.4$

$= 43.6\,N$