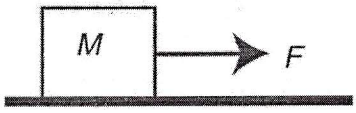
Free Body Diagrams & Tension

In the diagrams below, assume all pulleys and ropes are massless, and use the following variable definitions.

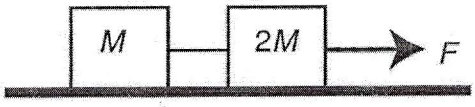
F= 10N M=1kg μ=0.2

Find the tension in each rope and the acceleration of the set of masses. (For a greater challenge, solve in terms of F, M and μ instead of plugging in values)

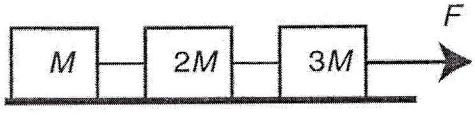
1. Frictionless



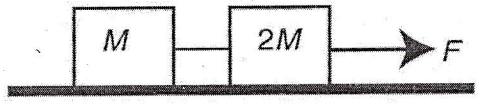
2. Frictionless



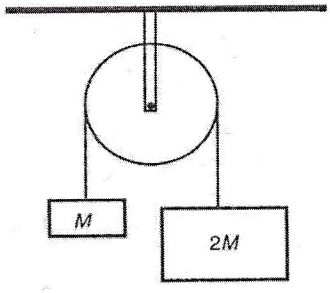
3. Frictionless



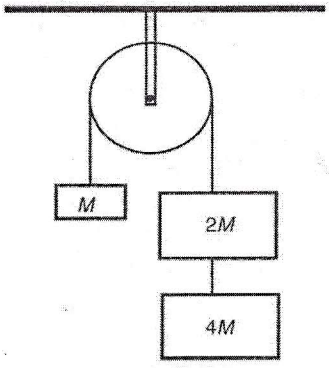
4. Coefficient of Friction μ



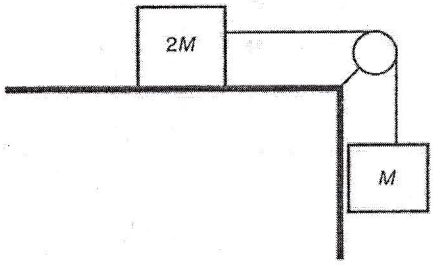
5.



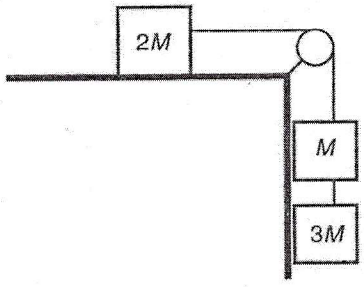
6.



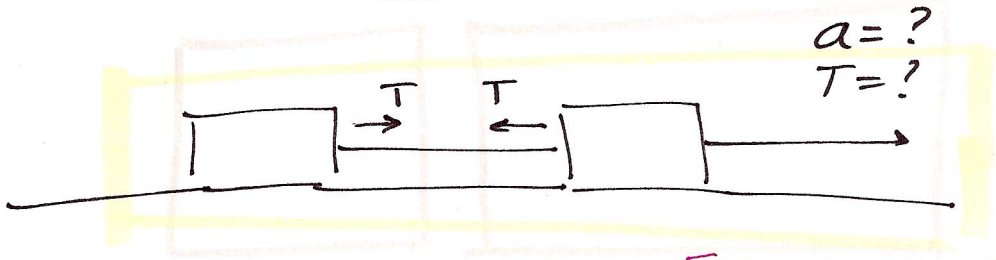
7. Frictionless



8. Frictionless



Tension problems



STEP 1: System analysis [Tension will cancel out]

$$\Sigma F = m_T \cdot a$$

m_T: total mass; a: acceleration of the system

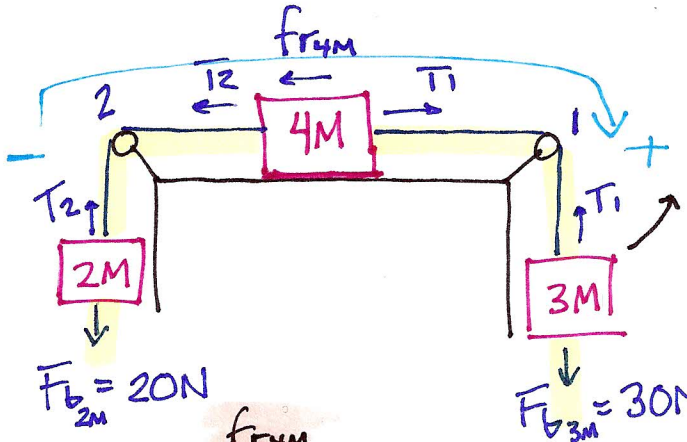
STEP 2: Individual BLOCK analysis → find Tension

(14)

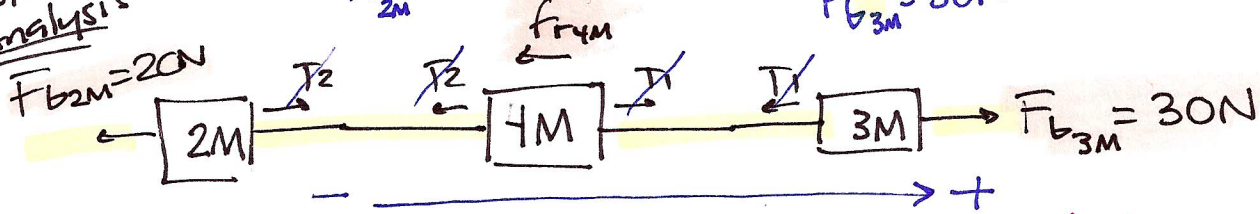
~~F = 10N~~

M = 1KG

$\mu = 0.2$



System Analysis



$\Sigma F = m \cdot a$

$F_{b_{3M}} - fr_{4M} - F_{b_{2M}} = m_T \cdot a$

$30 - 8N - 20 = 9 \cdot a$

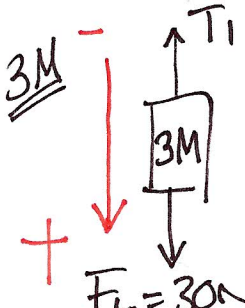
$a = \frac{2}{9} = 0.22\ m/s^2$

To get friction...

$f_r = \mu_K \cdot F_N$ (same as weight)

$f_r = (0.2)(40N) = 8N$

To Find Tension, we do individual block analysis

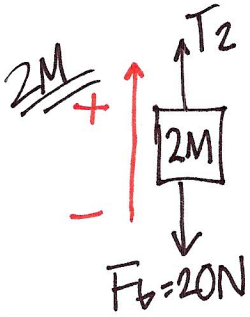


$\Sigma F_y = m \cdot a$

$F_b - T_1 = m \cdot a$

$T_1 = F_b - m \cdot a$

$T_1 = 30 - 3(.22) = 29.34N$



$\Sigma F_y = m \cdot a$

$T_2 - F_b = m \cdot a$

$T_2 - 20 = (2)(.22)$

$T_2 = 20.44N$