NAME :- SHREYAS SRINIVASA
PALOMAR I.D :- 01255187

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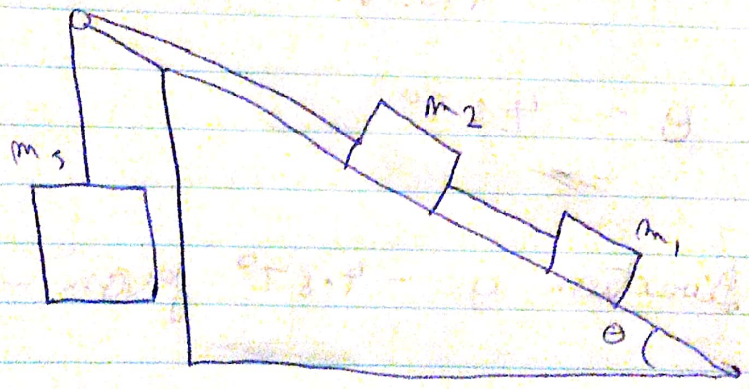
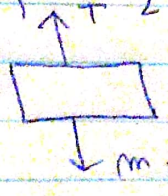
PHYS-230

LAB QUIZ #4

The diagram below represents a system consisting of three masses : $m_1 = 15$ kg, $m_2 = 20$ kg and $m_3 = 50$ kg. Two of them are on an incline and the other one hanging. The pulley is massless and frictionless and the ropes joining the masses are ideal. The angle of the incline is $\theta = 39°$. The coefficient of static friction between m_1 and the surface of the incline is $\mu_{s1} = 0.33$, and the coefficient of kinematic friction is $\mu_{k1} = 0.25$. The coefficient of static friction between m_2 and the surface of the incline is $\mu_{s2} = 0.22$, and the coefficient of kinematic friction is $\mu_{k2} = 0.15$. Determine whether the system is moving or not and, if it is, find its velocity after moving 20 cm (magnitude and direction).

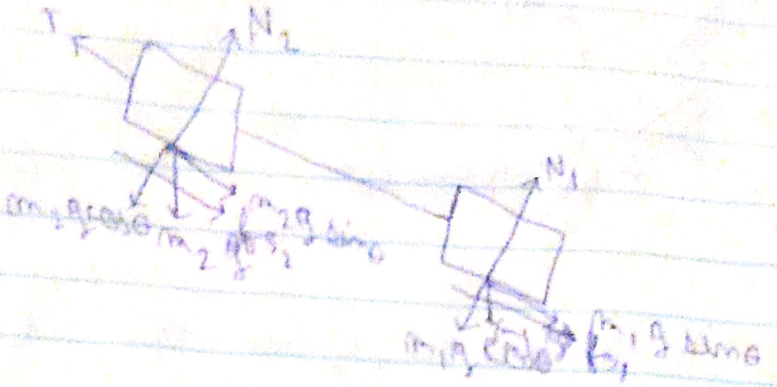


Ans: Given: $m_1 = 15$ kg, $m_2 = 20$ kg & $m_3 = 50$ kg



P.T.O

Free - body diagram (F.B.D) of both blocks together -



$N_1 = m_1 g \cos\theta = 15 \times 9.8 \cos(35°)$
$= 120.415\ N$

$N_2 = m_2 g \cos\theta = 20 \times 9.8 \cos(35°)$
$= 160.594\ N$

$f_{s1} = \mu_{s_1} N_1 = 0.33 \times 120.415$
$= 39.7369\ N$

$f_{s2} = \mu_{s_2} N_2 = 0.22 \times 160.594$
$= 35.3218\ N$

$\therefore T = m_1 g = 50 \times 9.8$
$= 490\ N$

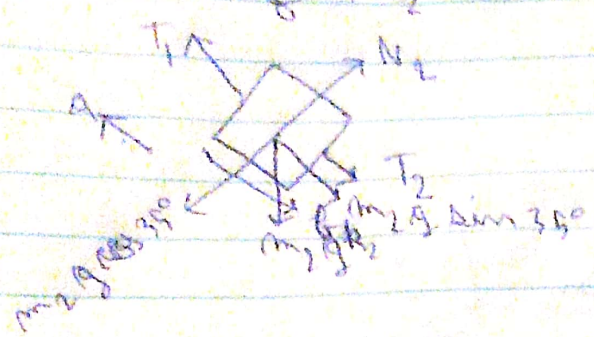
$\therefore T - (f_{s1} + f_{s2})$

$\Rightarrow 490 - (39.7369 + 35.3218)\ ?0$

So, the system will move $m_2 g - T_1 = m_2 a$

$\Rightarrow m_2 g - T_1 = m_2 a$
$\Rightarrow 50 \times 9.8 - T_1 = 50a$
$\Rightarrow T_1 = 490 - 50a$

F.B.D of m_2



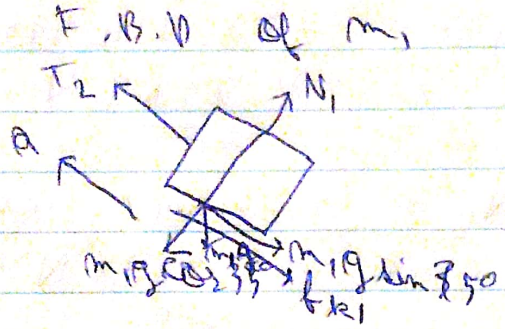
$$T_1 - T_2 - m_2 g \sin(35°) - f_{k_2} = m_2 A$$

$$\Rightarrow T_1 - T_2 = 112.42 - 0.15 \times 160.554 = 20A$$

$$\Rightarrow 490 - 50A - T_2 - 136.903 = 20A$$

$$\Rightarrow T_2 = 353.497 - 70A$$

F.B.D of m_1



$$T_2 - m_1 g \sin 35° - f_{k_1} = m_1 A$$

$$\Rightarrow 353.497 - 70A - 84.3157 - 0.24 \times 120.415 = 15A$$

$$\Rightarrow 239.0775 = 85A$$

$$\therefore A = \underline{2.8126 \text{ m/s}}$$

Now, $v^2 = u^2 + 2As$

$$\Rightarrow v^2 = 0 + 2 \times (2.8126) \times 20$$

$$\Rightarrow v = 10.6 \text{ m/s up the incline.}$$