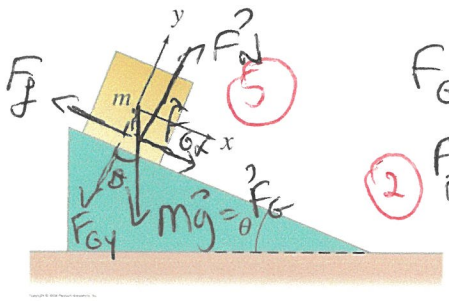
Name KEY

Problem 1: (33 Points)

The block shown in Fig. below has mass $m = 7.0$ kg and slides on a fixed rough plane tilted at an angle $\theta = 22°$ to the horizontal. The coefficient of sliding friction $\mu_k = 0.3$.

(a) Draw the Free Body Diagram



(5)

$F_G = mg$

(2) $f_f = \mu_k F_N$

$\sum \vec{F} = m\vec{a}$

$\sum F_x = F_{Gx} - f_f = ma$ (1)

(4)

$\sum F_y = F_N - F_{Gy} = 0 \Rightarrow F_N = F_{Gy}$

(4)

$F_N = F_G \cos\theta$ (2)

(*b*) Determine the acceleration of the block as it slides down the plane.

In (1): $F_G \sin\theta - f_f = ma$ (2)

$F_G \sin\theta - \mu_k F_N = F_G \sin\theta - \mu_k F_G \cos\theta = ma$

$mg(\sin\theta - \mu_k \cos\theta) = ma \Rightarrow a = g(\sin\theta - \mu_k \cos\theta)$ (2)

$a = 9.8 \frac{m}{s^2}(\sin 22 - (0.3)\cos 22) = 0.94 \, m/s^2$ (2)

(*c*) If the block starts from rest 12.0 m up the plane from its base, what will be the block's speed when it reaches the bottom of the incline?

$v^2 - v_0^2 = 2a\Delta x$ (4)

$v^2 = 2a\Delta x \Rightarrow v = \sqrt{2a\Delta x}$ (6)

$v = \sqrt{2(0.94 \frac{m}{s^2})(12.0 m)} = 4.75 m$

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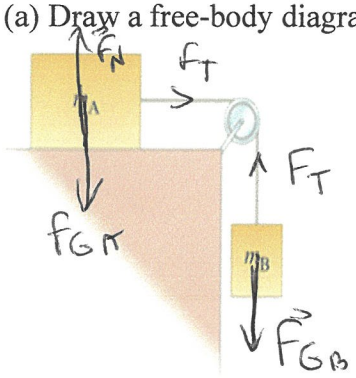
Problem 2: **(34 Points)**

The Figure below shows a block of mass m_A on a smooth horizontal surface, connected by a thin cord that passes over a pulley to a second block of mass m_B which hangs vertically. Ignore friction and the masses of the pulley and cord.

(a) Draw a free-body diagram for each block,



x
y (7)

$\Sigma \vec{F} = m\vec{a}$

(b) Apply Newton's second law to find formulas for the acceleration of the system and for the tension in the cord.

A: x: $\Sigma \vec{F}_x = m_A \vec{a}_x$ (2)

(2) $F_T = m_A a$ (1)

y: $\Sigma F_y = m_A a_y = 0$ (no motion on y)

$F_{GA} - F_N = 0 \Rightarrow F_N = F_{GA} = m_A g$ (4)

B: $F_{GB} - F_T = m_B a$ (2)

$F_T = m_A a$ (1) (4)

$F_{GB} = (m_B + m_A) a$ (3) $\Rightarrow m_B g = (m_A + m_B) a$ (2)

$\Rightarrow a = \frac{m_B g}{m_A + m_B}$ (3)

$F_T = m_A a = \frac{m_A m_B g}{m_A + m_B}$ (5)

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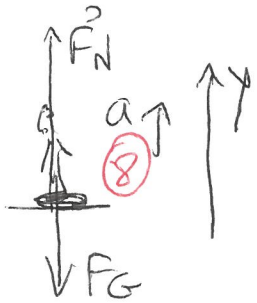
Problem 3: (33 Points)

You know your mass is 65 kg, but when you stand on a bathroom scale in an elevator, it says your mass is 76 kg. What is the acceleration of the elevator, and in which direction?



F_N is the reading of the scale $= W' = m'g$

$\Sigma \vec{F} = m\vec{a}$ (4)

$F_N - F_G = ma$ (4)

$a = \frac{F_N - F_G}{m}$ (4)

$a = \frac{m'g - mg}{m}$ (4)

$a = \frac{g(m' - m)}{m} = 9.8\frac{m}{s^2}\left(\frac{76\,kg - 65\,kg}{65\,kg}\right) = 1.65\,m/s^2$ (3)

(2) $m = 65$ kg reading bathroom

(2) $m' = 76$ kg (apparent mass elevator moving)

(2) a is positive, so the acceleration is upward