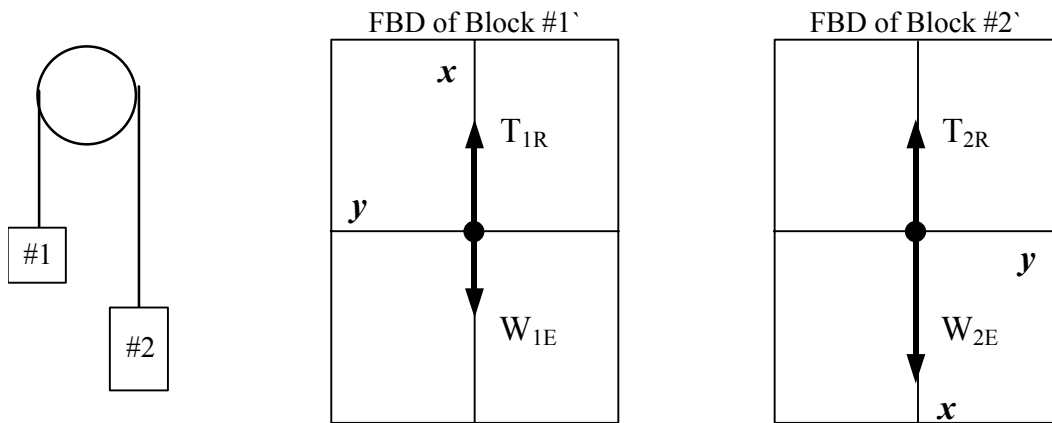


HOMEWORK Solutions #3: Forces I (Phys 207, Fall 2005)**QUIZ #3 on HW#3** THIS Thursday (9/22) at BEGINNING of class**Problem #1: Moving Vertical Blocks (Atwood's Machine)**

Two blocks are connected by a massless string that slides over a frictionless peg as shown below (called an Atwood's machine). Assume that Block #2 is heavier and that the blocks accelerate such that Block #1 rises and Block #2 falls.

- (a) Draw the **free body diagrams** for blocks #1 and #2 in the indicated boxes. Use **SUBSCRIPT notation** to label ALL vectors with appropriate labels as done in class, e.g. W_{1E} , T_{1R} , etc. Mark on the axes drawn in the boxes where the **+x and +y axes** are located. Remember that +x must be in the direction of motion for each block (labels shown in FBD #1 as an example).



- (b) Write down $\sum F_x = ma_x$ for blocks #1 and #2 using the notation in the FBD's.

$$\sum F_{1x} = T_{1R} - W_{1E} = m_1 a \quad (\text{Eqn. \#1})$$

$$\sum F_{2x} = W_{2E} - T_{2R} = m_2 a \quad (\text{Eqn. \#2})$$

- (c) Use the force equations in part (b) to find an **algebraic** expression for the **acceleration a** of the blocks in terms of m_1 , m_2 , and g .

>> Add Eqn. #1 and Eqn. #2 from part (b) and solve for a .

$$(T_{1R} - W_{1E}) + (W_{2E} - T_{2R}) = m_1 a + m_2 a$$

$$\text{where } W = mg \text{ and } T_{1R} = T_{2R}$$

$$(T_{1R} - m_1 g) + (m_2 g - T_{1R}) = m_1 a + m_2 a$$

$$a = \frac{m_2 g - m_1 g}{m_1 + m_2}$$

- (d) Calculate the **numerical** value for the **acceleration a** if: $m_1 = 1.5 \text{ kg}$ and $m_2 = 4.5 \text{ kg}$. How does this value compare to the "free-fall" value of g .

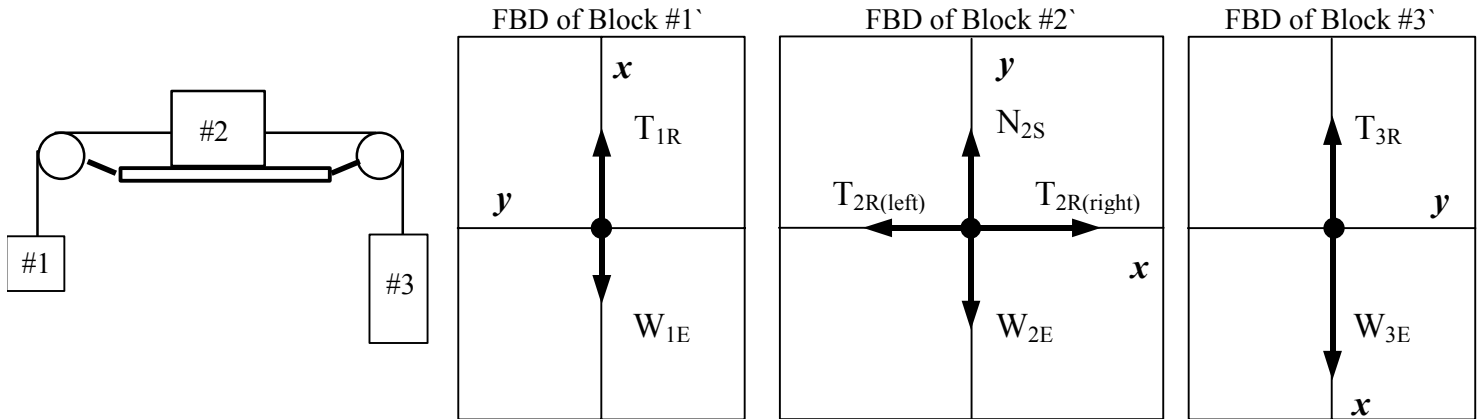
$$a = \frac{(4.5 \text{ kg} - 1.5 \text{ kg})(9.8 \text{ m/s}^2)}{1.5 \text{ kg} + 4.5 \text{ kg}} = 4.9 \text{ m/s}^2$$

>> This acceleration is about **1/2** the acceleration due to gravity.

Problem #2: Moving Horizontal and Vertical Blocks

Three blocks are connected by two massless strings that slide over frictionless pegs as shown below. There is also no friction between block #2 and the horizontal surface. Assume that Block #3 is heavier than Block #1 and the blocks accelerate such that Block #1 rises and Block #3 falls.

- (a) Draw the **free body diagrams** for blocks #1, #2, and #3 in the indicated boxes. Use **SUBSCRIPT notation** to label ALL vectors with appropriate labels as done in class, e.g. W_{2E} , $T_{2R(left)}$, $T_{2R(right)}$, N_{2S} , etc. Mark on the axes drawn in the boxes where the **+x and +y axes** are located.



- (b) Write down $\sum F_x = ma_x$ for blocks #1, #2, and #3 using the notation in the FBD's.

$$\sum F_{1x} = T_{1R} - W_{1E} = m_1 a \quad (\text{Eqn. \#1})$$

$$\sum F_{2x} = T_{2R(right)} - T_{2R(left)} = m_2 a \quad (\text{Eqn. \#2})$$

$$\sum F_{3x} = W_{3E} - T_{3R} = m_3 a \quad (\text{Eqn. \#3})$$

- (c) Use the force equations in part (b) to find an **algebraic** expression for the **acceleration a** of the blocks in terms of m_1 , m_2 , m_3 , and g .

>> Add Eqns. #1, #2, and #3 from part (b) and solve for a .

$$(T_{1R} - W_{1E}) + (T_{2R(right)} - T_{2R(left)}) + (W_{3E} - T_{3R}) = m_1 a + m_2 a + m_3 a$$

$$\text{where } W = mg, \quad T_{1R} = T_{2R(left)}, \quad T_{3R} = T_{2R(right)}$$

$$(T_{1R} - m_1 g) + (T_{3R} - T_{1R}) + (m_3 g - T_{3R}) = m_1 a + m_2 a + m_3 a$$

$$a = \frac{m_3 g - m_1 g}{m_1 + m_2 + m_3}$$

- (d) Calculate the **numerical** value for the **acceleration a** if: $m_1 = 1.5 \text{ kg}$, $m_2 = 2 \text{ kg}$ and $m_3 = 4.5 \text{ kg}$. How does this value compare to problem #1 which is identical except for the center block?

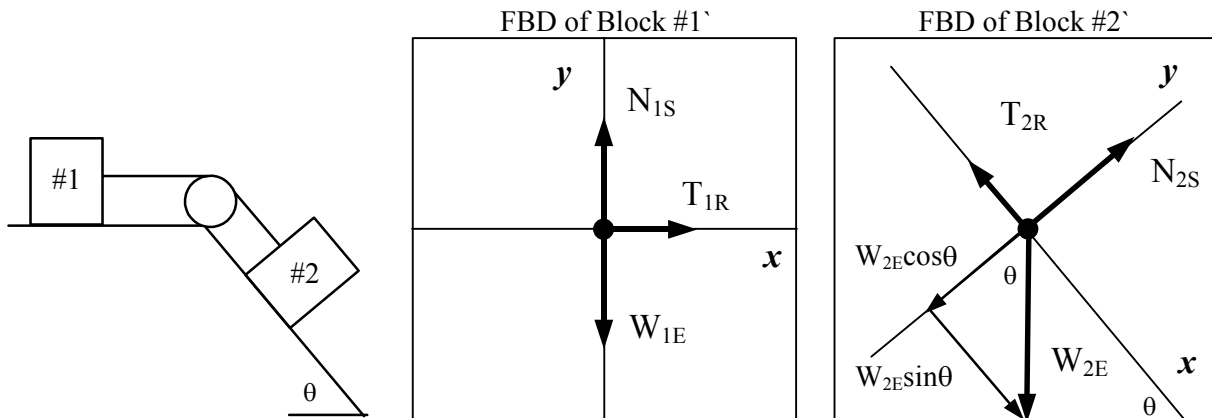
$$a = \frac{(4.5 \text{ kg} - 1.5 \text{ kg})(9.8 \text{ m/s}^2)}{1.5 \text{ kg} + 2 \text{ kg} + 4.5 \text{ kg}} = 3.7 \text{ m/s}^2$$

This acceleration is smaller because the “driving” force is the same, but the total inertial mass of the system is now larger.

Problem #3: Moving Horizontal and Inclined Plane Blocks

Two blocks of mass m_1 and m_2 are connected by a massless string that slides over a frictionless peg as shown below. Block #1 is on a frictionless horizontal surface and block #2 is on a frictionless incline with angle θ .

- (a) Draw the **free body diagrams** for blocks #1 and #2 in the indicated boxes. Use **SUBSCRIPT notation** to label ALL vectors with appropriate labels as done in class, e.g. W_{1E} , T_{1R} , etc. Mark on the axes drawn in the boxes where the **+x and +y axes** are located. Also, draw and label the x- and y- component vectors for any forces not aligned along the indicated axes, e.g. for W_{2E} .



- (b) Write down $\sum F_x = ma_x$ for blocks #1 and #2 using the notation in the FBD's.

$$\sum F_{1x} = T_{1R} = m_1 a \quad (\text{Eqn. \#1})$$

$$\sum F_{2x} = W_{2E} \sin \theta - T_{2R} = m_2 a \quad (\text{Eqn. \#2})$$

- (c) Use the force equations in part (b) to find an **algebraic** expression for the **acceleration a** of the blocks in terms of m_1 , m_2 , θ and g .

>> Add Eqns. #1 and #2 from part (b) and solve for a .

$$T_{1R} + (W_{2E} \sin \theta - T_{2R}) = m_1 a + m_2 a \quad \text{where } W = mg \text{ and } T_{1R} = T_{2R}$$

$$T_{1R} + (m_2 g \sin \theta - T_{1R}) = m_1 a + m_2 a$$

$$a = \frac{m_2 g \sin \theta}{m_1 + m_2}$$

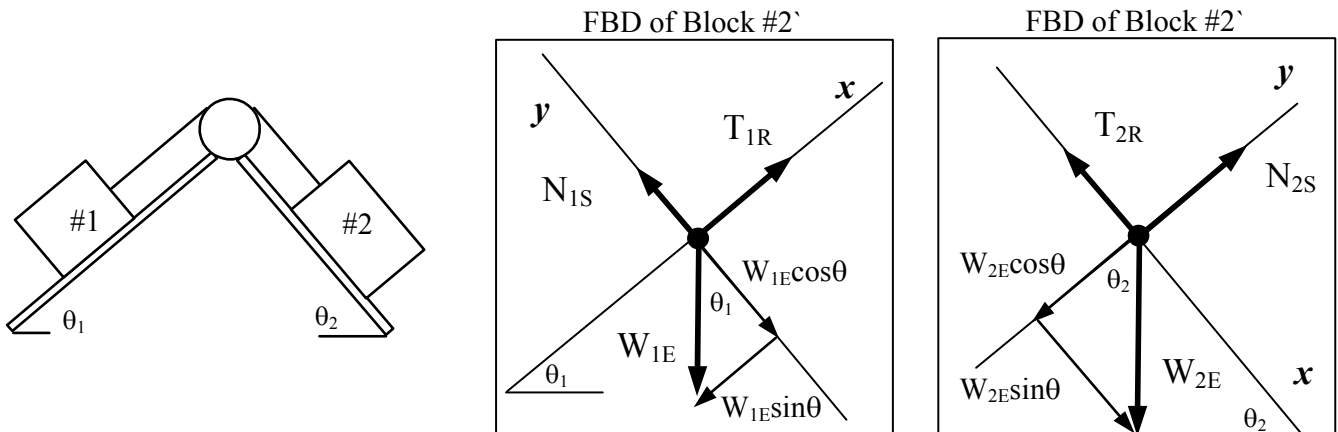
- (d) Calculate the **numerical** value for the **acceleration a** if: $m_1 = 1.5 \text{ k}$, $m_2 = 4.5 \text{ kg}$, and $\theta = 35^\circ$.

$$a = \frac{(4.5 \text{ kg})(9.8 \text{ m/s}^2) \sin 35^\circ}{1.5 \text{ kg} + 4.5 \text{ kg}} = 4.2 \text{ m/s}^2$$

Problem #4: Moving Blocks on Inclined Planes

Two blocks are connected by a massless string that slides over a frictionless peg as shown below. There is also no friction between the blocks and inclined surfaces. Assume that Block #2 is heavier than Block #1 and the blocks accelerate such that Block #1 rises and Block #2 falls.

- (a) Draw the **free body diagrams** for blocks #1 and #2 in the indicated boxes. Use **SUBSCRIPT notation** to label ALL vectors with appropriate labels as done in class, e.g. W_{1E} , T_{1R} , etc. Mark on the axes drawn in the boxes where the **+x and +y axes** are located. Also, draw and label the x- and y-component vectors for any forces not aligned along the indicated axes.



- (b) Write down $\sum F_x = ma_x$ for blocks #1 and #2 using the notation in the FBD's.

$$\sum F_{1x} = T_{1R} - W_{1E} \sin \theta = m_1 a \quad (\text{Eqn. \#1})$$

$$\sum F_{2x} = W_{2E} \sin \theta - T_{2R} = m_2 a \quad (\text{Eqn. \#2})$$

- (c) Use the force equations in part (b) to find an **algebraic** expression for the **acceleration a** of the blocks in terms of m_1 , m_2 , θ_1 , θ_2 , and g .

>> Add Eqns. #1 and #2 from part (b) and solve for a .

$$(T_{1R} - W_{1E} \sin \theta_1) + (W_{2E} \sin \theta_2 - T_{2R}) = m_1 a + m_2 a \quad \text{where } W = mg \text{ and } T_{1R} = T_{2R}$$

$$(T_{1R} - m_1 g \sin \theta_1) + (m_2 g \sin \theta_2 - T_{1R}) = m_1 a + m_2 a$$

$$a = \frac{m_2 g \sin \theta_2 - m_1 g \sin \theta_1}{m_1 + m_2}$$

- (d) Calculate the **numerical** value for the **acceleration a** if: $m_1 = 1.5 \text{ kg}$, $m_2 = 4.5 \text{ kg}$, $\theta_1 = 35^\circ$, and $\theta_2 = 45^\circ$.

$$a = \frac{[(4.5 \text{ kg})(\sin 45^\circ) - (1.5 \text{ kg})(\sin 35^\circ)](9.8 \text{ m/s}^2)}{1.5 \text{ kg} + 4.5 \text{ kg}} = 3.8 \text{ m/s}^2$$