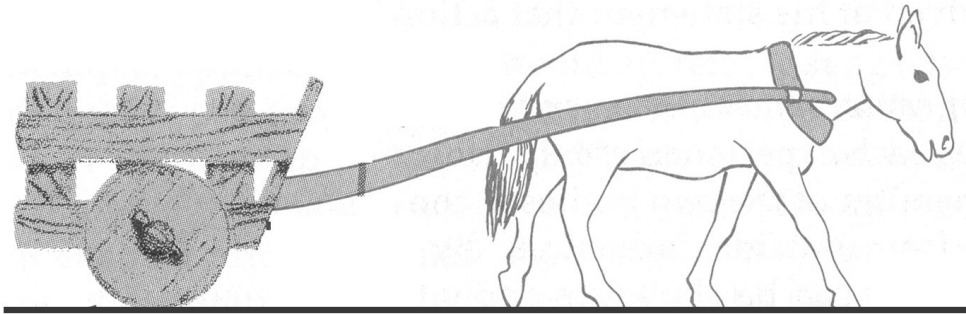


## Force Problems – Set 2

1

A horse (Mr. Ed) refuses to pull a cart. He reasons, “According to Newton’s 3<sup>rd</sup> law, whatever force I exert on the cart, the cart will exert an equal and opposite force on me. The resultant force must be zero and I have no chance of moving the cart.”

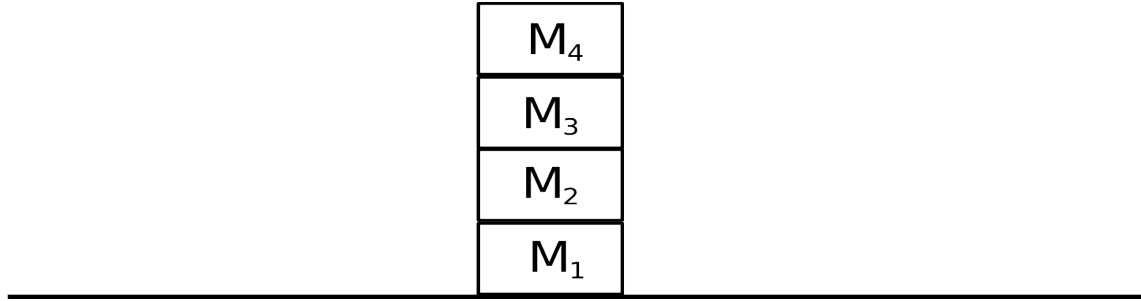
On the diagram of the cart, horse and ground show all action-reaction pairs and use the diagram to discuss what is wrong with the horse’s reasoning.



## Force Problems – Set 2

2

In the picture below, four blocks are stacked on top of each other. Nothing is in motion.



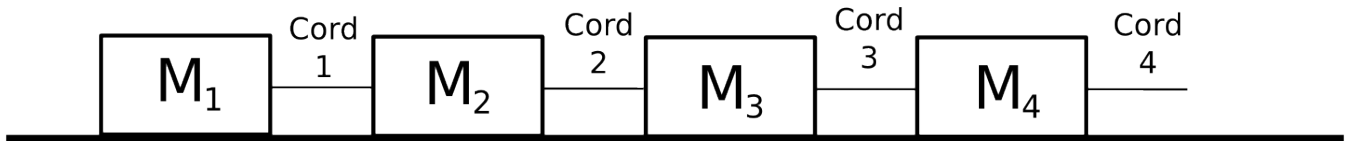
a) Draw a free body diagrams for each block.

b) Rank the reaction forces from the free body diagrams above in order of magnitude, greatest first. If any are equal, place an equals sign between them.

## Force Problems – Set 2

3

The picture below shows four blocks connected by chords. The system is accelerated to the right by pulling on cord 4.

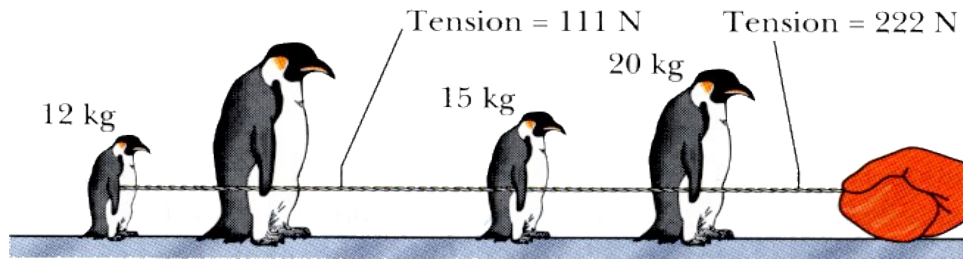


- Rank the blocks according to their acceleration, greatest first.
- Rank the cords according to their tension, greatest first.
- Which is greater: The total mass accelerated by cord 4 or the total mass accelerated by cord 1?

## Force Problems – Set 2

4

Four penguins are being playfully pulled along a very slippery (frictionless) ice by a zoo keeper. The masses of the first, second, and third penguins and two cord tensions are shown below. Find the mass of the third penguin.



a) Draw four free body diagrams, one for each penguin. Keep very careful track of the tension forces. State the given information.

b) Write Newton's Second Law for each free body diagram.

c) Solve the system of equations above to isolate the mass of the fourth penguin.

## Force Problems – Set 2

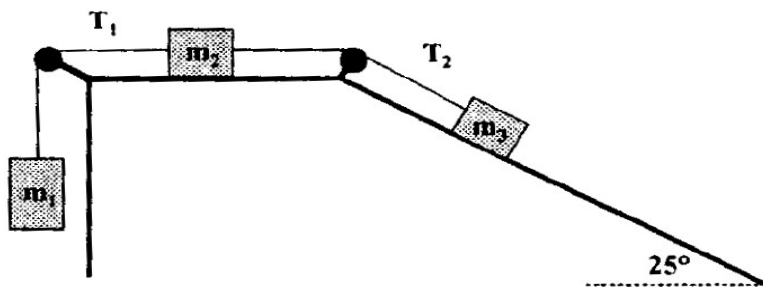
5

For the following situations, draw free-body diagrams to indicate all forces acting on the object(s) in question. *Indicate relative magnitudes of forces by drawing long, short, or equal-length vectors.*

a) A block is being pushed across a rough horizontal table at a constant velocity (there's friction).

b) A block is resting on a rough incline plane without sliding.

c) Three blocks are attached by strings as in the diagram. All surfaces are rough. Draw free body diagrams of each block.



## Force Problems – Set 2

6

A block rests on an incline plane that makes an angle  $\theta$  with the horizontal. The coefficient of static friction between the block and the plane is  $\mu_s$  and the coefficient of kinetic friction is  $\mu_k$ .

a) Find an expression for the maximum angle of the incline before the block slips.

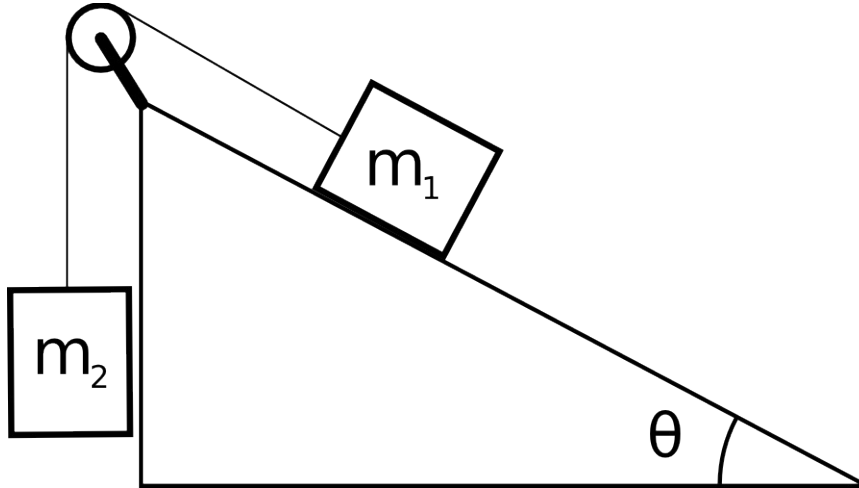
*HINT: The equation for the force of static friction ( $F = \mu_s N$ ) represents the **maximum** force that friction can provide.*

b) Assuming that the block is in motion, find an expression for the acceleration of the block in terms of  $\theta$  and  $\mu_k$ .

## Force Problems – Set 2

In the picture below, the coefficient of kinetic friction between the ramp and  $m_1$  is  $\mu_k$ . A rope connecting  $m_1$  and  $m_2$  passes over a massless frictionless pulley.

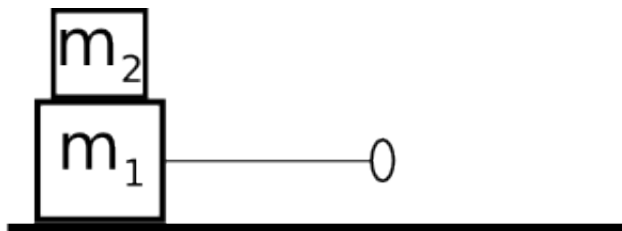
Calculate the acceleration of the system.



## Force Problems – Set 2

8

Two blocks with masses  $m_1$  and  $m_2$  are stacked up as shown in the picture below. A rope with a handle is attached to  $m_1$  as shown. There is no friction between  $m_1$  and the table. The coefficient of static friction between  $m_2$  and  $m_1$  is  $\mu_s$ .



- Draw free body diagrams for  $m_1$  and  $m_2$ .
- Find an expression for the maximum force that can be applied to the rope on  $m_1$  without  $m_2$  slipping.
- Find an expression for the reaction force of the floor acting on  $m_1$  in terms of  $g$ ,  $m_1$ , and  $m_2$ .



## Force Problems – Set 2

One end of a rope is connected to a mass  $M_1=10\text{kg}$ . The rope passes over a massless frictionless pulley and the other end is connected to a mass  $M_2 = 5\text{kg}$ .  $M_2$  is initially resting on the ground and  $M_1$  is suspended  $3\text{m}$  above the ground. The system is initially at rest.

If  $M_1$  is released and allowed to hit the ground, what is the maximum height that  $M_2$  will reach?

*HINT: When  $M_1$  hits the ground,  $M_2$  will still have an upward velocity.  $M_2$  will **continue** upward until its velocity is zero.*

