NII(6).t2: Dynamics & Statics

Physics 203, Profs. Daniel Yaverbaum & Max Bean
John Jay College of Criminal Justice, the CUNY

I. Warm Up in 1 Dimension

An ice-skater with a mass of 60 kg pushes off from the wall of the ice rink and glides out across the ice with an initial velocity of 3m/s. The ice exerts a slight but non-negligible frictional force on the skater of 2N. How far will the ice skater travel before coming to a complete stop? ***If and only if*** you are ***stuck***, try the hints below:

Hint #1: What is the acceleration of the ice-skater? (Try an FBD.)
Hint #2: How much time will it take the ice-skater to come to a stop?

II. Friction Warm Up

A child sleds down a hill. When she reaches the bottom, she is going 11 m/s. She then sleds ***across level ground*** until she slows down and comes to rest. The coefficient of kinetic friction between the sled and the snow is given as $\mu_k = 0.1$. The sled weighs 4kg and the child weighs 25 kg.

A) Draw a picture of this situation as you understand it.
B) Draw a System Schema for the situation.
C) Draw an FBD of the sled-child system during the time they are sledding ***on level ground***.
D) What is the force of kinetic friction on the sled-child system?

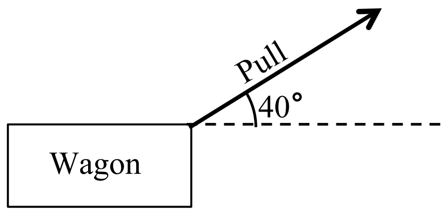
Hint #1: What is the normal force on the sled.
Hint #2: Treat the sled and the kid as a single system.

E) How far will they go before coming to rest?

Hint #1: first find the acceleration of the sled, using Newton's laws.
Hint #2: to find a, first draw an SS and an FBD.
Hint #3: once you've found a, use kinematics to find displacement.

III. Wagon Pull

A child is pulling a ***wagon*** along a ***road*** at an angle 40° above the horizontal, as shown:



The wagon has a mass of 2kg, and the child pulls with a force of 4N.
All frictional forces are negligible.

A) Create a drawing of this situation and a system schema.
B) Create an ***pure*** FBD of the wagon. (Your FBD will have three arrows.)
C) Create a ***component*** FBD of the wagon using a vertical-horizontal coordinate system. (Your FBD will have four arrows.)

Hint: the component FBD looks just like the pure FBD, except that the tension force is split into vertical & horizontal components

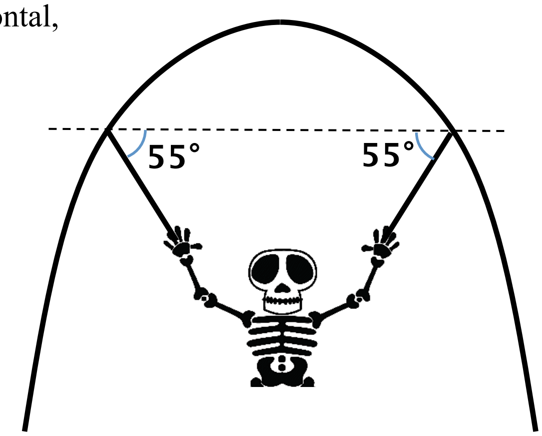
D) Show that the wagon will remain on the ground despite the upward pull from the child.

Hint 1: staying on the ground means vertical acceleration is zero.
Hint 2: if wagon leaves ground, normal force from road drops to zero.

E) Find the horizontal acceleration of the wagon.

IV. Halloween Hang

A **20kg** skeleton is suspended by diagonal chains in an archway, as shown below: Each chain forms a **55 degree** angle with the horizontal, and the weight of the skeleton is evenly distributed across the chains—that is, the force of tension on one chain is the same as the force of tension on the other. The skeleton is ***not moving.***



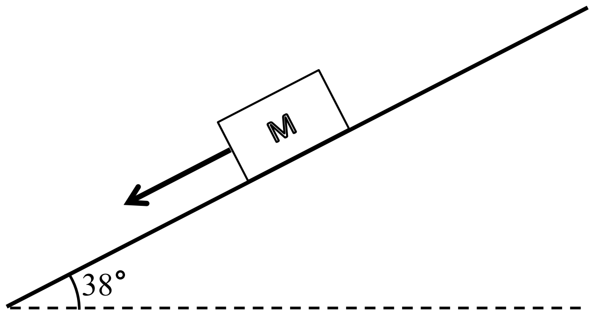
A) Draw a system schema of the situation.
B) Draw a ***pure*** FBD for the skeleton.
C) Draw a ***component*** FBD for the skeleton.
D) Calculate the magnitude of the force of tension on each chain.

Use the hints if you get stuck.

Hint #1: The shape of the arch makes no difference.
Hint #2: To draw the component FBD, split all diagonal forces into components
Hint #3: What is the vertical acceleration? What is the horizontal acceleration?
Hint #4: Since you know the force of gravity, you know something about the vertical direction. Therefore, use the vertical direction to figure out magnitude of F_T

V. Frictional Galileo Track

Mass M is sliding down a ***rough*** track. The track forms a 38 degree angle with the horizontal. The mass has a coefficient of kinetic friction with the track of 0.3.



Your goal: find an expression for the ***a***, acceleration of the mass

A) Create a system schema for this situation.
B) Create a ***pure*** FBD of the mass.
C) Create a coordinate system ***in which the x-axis lines up with the direction of acceleration***. In other words, the x-axis will be in ***the direction the block is actually moving***. As always, the y-axis will be ***perpendicular*** to the x-axis. The x-axis will ***not*** be horizontal. The y-axis will ***not*** be vertical.
D) Create a ***component*** FBD of the mass.
E) Set up a Newton's 2^{nd} Law equation for the y-components.
F) What is the acceleration of the mass in the y-direction?
G) Solve for the magnitude of the normal force between the track and the mass.
H) Set up a Newton's 2^{nd} Law equation for the x-components.
I) Solve for ***a***.

VI. Written Responses & Reflections

A) Give one example of an non-external force.
B) Give one example of a non-net external force.
C) In the Halloween Hang (problem IV), why did you use the vertical direction to find the tension in the chains? Why could you ***not*** have found it using the horizontal direction?
D) In both Wagon Pull (III) and Frictional Galileo Track (V), you used a coordinate system to split vectors into components. How and why were these coordinate systems different from each other?
E) When an apple sits on a table, the normal force perfectly balances gravity. On the Galileo Track it does not? Why not and what is the effect of this imbalance?