

APPC, Mechanics: Unit β HW 1

Name: _____

Hr: ____ Due at beg of hr on: _____

U β , HW1, P1

Reference Videos: (1) "Inclined Plane Problems (Ramp Problems)"

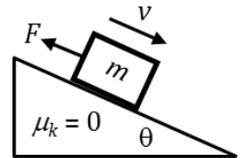
(2) "Part II: Inclined Plane Problems"

YouTube, lasseviren1, NEWTON'S LAWS OF MOTION playlist

A. The steps in solving a Newton's 2nd law problem are:

- i. Choose a _____.
- ii. Draw all of the _____ ON the _____ by sketching a _____.
- iii. Choose a _____, and have one of the _____ point in the direction of any acceleration.
- iv. Set up Newton's 2nd law in both directions by writing equations that have WHAT general form? NOTE: I prefer the 'no denominator' form of this equation; the narrator prefers the 'yes denominator' form; either one is fine for this answer.

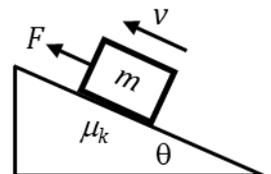
B. A mass m is sliding down a frictionless surface inclined at an angle θ . Although it is NOT enough to prevent m from moving downward, a force F is being applied parallel to the incline and is directed UP the ramp. See the figure at right.



- i. On the dot at right, draw a correct free body diagram (FBD), showing ONLY the three forces that act on the mass. DO NOT show components of any forces. Each force vector should originate ON the dot. ●
- ii. Near this next dot, draw and label your chosen coordinate system. ON the dot, modify your previous free body diagram to now show ONLY the forces OR force components (but NOT both!) that act along your chosen axes. ●
- iii. Write the Newton's 2nd law equation(s) that is/are necessary and solve it/them to obtain an expression for the mass's acceleration down the ramp.

C. Repeat the three steps of Part B for a new case. This time, the applied force F is sufficient to accelerate the mass UP the ramp, and this time there IS friction.

- i. FBD (NO components) ●
- ii. axes and FBD (YES components) ●

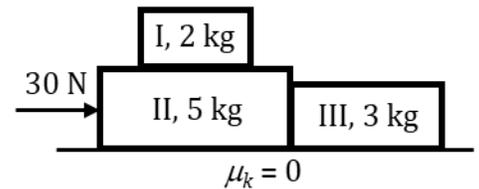


- iii. Newton's 2nd law equation(s) and an expression for acceleration up the ramp

Uß, HW1, P2

Reference Video: "Multiple Body Problems and Newton's Laws"
YouTube, lasseviren1, NEWTON'S LAWS OF MOTION playlist

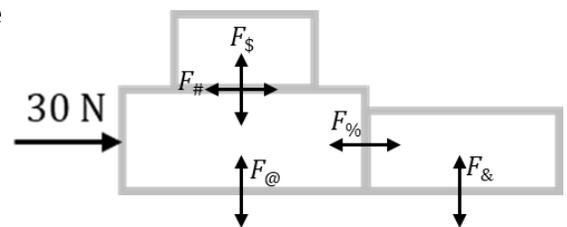
When addressing multiple-body problems, it is important to realize that "the system" at any given moment IS WHAT WE SAY IT IS...and... that Newton's 2nd and 3rd laws apply to that specific system. So, within the same problem, we will modify the system as necessary to achieve whatever ends we seek, remembering always that Newton's 2nd and 3rd laws NEVER FAIL to apply to any mechanical system.



The figure above-right shows a system of three blocks being pushed by an applied force across a frictionless, horizontal surface. There is, however, friction between Blocks I and II, such that Blocks I and II will NOT slide, relative to each other. For simplicity, use $g = 10 \text{ m/s}^2$. (You will NOT need a calculator.)

- A. First, let's take the system to be Blocks I, II, and III, as a whole. This system's mass is _____ kg.
- B. Newton's 2nd law says that ALL PARTS of the system of Part A will have what acceleration?

From Newton's 3rd law, when – for instance – Block I exerts a force on Block II, then Block II will exert an equal and opposite force back on Block I. These are **internal forces** IF the two blocks are BOTH a part of the system we are focused on. These become TWO SEPARATE, EXTERNAL forces IF one of the blocks that we're dealing with is NOT a part of the system. For multiple-body problems, I like to show these forces as double-sided arrows, as shown at right. We will then use them as needed to figure out the magnitudes of each force. Here we go...



- C. Now, make Block III a system. Given your Part B answer, what must the magnitude of $F_{\%}$ be? (Note that when only III is the system, $F_{\%}$ becomes an EXTERNAL force on THAT system.)
- D. Let's say that now Blocks I and II constitute the system. What is the mass of that system?
- E. For the Blocks-I-and-II system, note that $F_{\%}$ and $F_{\#}$ are internal forces, and CANNOT be considered when analyzing the motion of THAT specific system. Therefore, use ONLY the given applied force and your Parts B, C, and D answers in a Newton's 2nd law equation to show that everything we've done so far is valid and correct.
- F. If Block III is the system, what is the magnitude of $F_{\&}$?
- G. If Blocks I and II are the system, what is the magnitude of $F_{\@}$? (Again, $F_{\%}$ and $F_{\#}$ are internal forces here.)
- H. If Block I is the system, what is the magnitude of $F_{\%}$?
- I. If Block I is the system, what is the magnitude of $F_{\#}$?
- J. Finally, why weren't there any horizontal forces between the surface and Blocks II and III?

Uß, HW1, P3

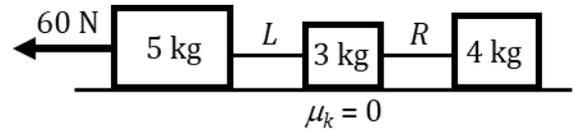
Reference Videos: (1) "Atwood's Machine Problems"

(2) "Part II: Atwood's Machine Problems"

YouTube, lasseviren1, NEWTON'S LAWS OF MOTION playlist

Atwood's machine problems are a specific case of multiple-body problems, so let's review those quickly.

A. With reference to the figure at right, use the ideas of multiple-body problems to determine:



i. the acceleration of the three-block system

ii. the tension in Rope L

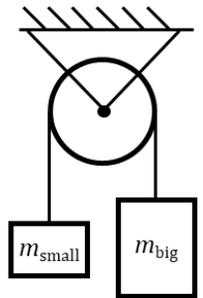
iii. the tension in Rope R

B. List the three assumptions that we make in this unit when solving Atwood's machine problems:

i.

ii.

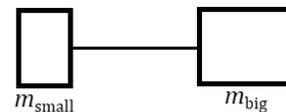
iii.



B. The Atwood's machine above-right is fixed to the ceiling.

At right, draw a free-body diagram of an equivalent system that has been stretched out horizontally.

Do NOT show internal forces; only external forces.

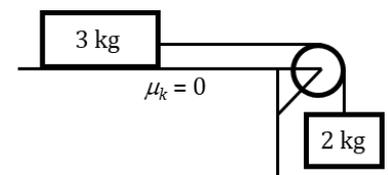


C. Use your Part B answer to help you obtain an expression for the acceleration of the system.

D. Now, focus only on m_{small} , i.e., ignore m_{big} . Use your Part

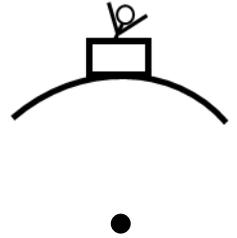
C answer and m_{small} to obtain an expression for the rope's tension. (An equivalent expression can be found by focusing on m_{big} , but don't worry about that.)

E. With reference to the figure at right, use the techniques shown in the second video to determine the acceleration of the system and the tension in the rope. For simplicity, use $g = 10 \text{ m/s}^2$.



A. In uniform circular motion (UCM), an object is traveling in a circle at a _____ speed. In UCM, the magnitude of the object's acceleration is equal to the mathematical expression _____. This acceleration is termed "_____ acceleration" and is always directed/pointed _____ of the circular path.

In the figure at right, a person sits right-side-up in a roller coaster car as the car travels over a high point on the ride. The person has mass m and is traveling with speed v . This portion of the roller coaster ride has a radius of R .



B. The dot at right represents the person. Draw the correct FBD – i.e., show and label all forces, being sure they originate ON the dot – for the person in the situation described above. Also, the relative lengths of your force vectors should mean something.

C. With reference to your Part B answer...Explain briefly how you knew to draw the force vectors to the relative lengths you did.

D. Write, but do NOT solve, a Newton's 2nd law equation that takes into account your Parts A-C answers.

E. Now, solve your Part D answer to obtain an expression for the normal force (i.e., the force from the seat) that acts on the person.

F. What does the value of the normal force become if the car is moving so fast that the person is launched off of the seat?

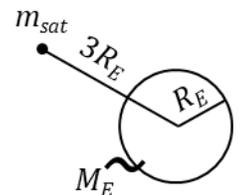
G. Use your Parts E and F answers to derive an expression for the lowest speed the car could possibly have that would result in the person being launched off of the seat.

H. Look at your Part G answer. Does the mass of the person affect this minimum speed?

At right is a diagram of a satellite at a certain distance from Earth's center.

I. What type of force is acting between the Earth and the satellite?

J. Using the variables given in the diagram and one or more fundamental constants, write an expression for the magnitude of the force you mentioned in your Part I answer.



K. We want the satellite to experience UCM at the distance shown in the figure. Write, but do NOT solve, a Newton's 2nd law equation that applies to this criterion.

L. Now, solve your Part K answer to obtain an expression for the required speed of the satellite.

Uß, HW1, P5

Reference Video: "Physics of Circular Motion (Part II)"

YouTube, lasseviren1, NEWTON'S LAWS OF MOTION playlist

The figure at right shows a car driving directly toward you, i.e., out of the page. The car is driving on a level surface, in a circle, with center of the circle on, say, the leftmost edge of this page. The car has a mass m , is traveling in UCM at a speed v , and is a distance R away from the center of its circular path.



A. The force that keeps the car in a circular path is a type of friction, and it is much more like _____ friction than _____ friction. Therefore, here, we will give the frictional force the familiar label of _____. Normally, there is NO standard equation that always applies to this force; however, when this force is maximized (as we will assume below) it conforms to the equation _____.

B. The dot at right represents the car. Draw the correct FBD – i.e., show and label all forces, being sure they originate ON the dot – for the car in the situation described above.



C. Write and fully simplify the Newton's 2nd law equation that applies in the vertical direction.

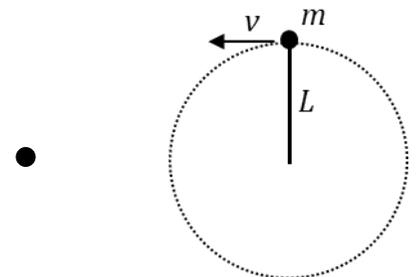
D. We now assume that the car is traveling at the maximum speed possible for the car to NOT slide, v_{\max} . Write – but do NOT solve – a Newton's 2nd law equation that contains ONLY (a) info given at the top of this page, (b) info from your FBD, and (c) the given coefficient of friction μ_s .

E. Combine your Parts C and D answers to obtain an expression for v_{\max} .

A rock of mass m is at the end of a rope of length L . The stone is being whirled in a vertical circle and has a speed v at the top of its path, which is enough to keep the rope straight. See the figure at right.

F. Draw an FBD of the forces acting on the rock at the instant shown.

G. Derive an expression for the tension in the rope, so long as the speed is sufficient to keep the rope straight.



H. Use your Part G answer to derive an expression for the speed the rock would have to have at the top for the rope to just begin to go slack.