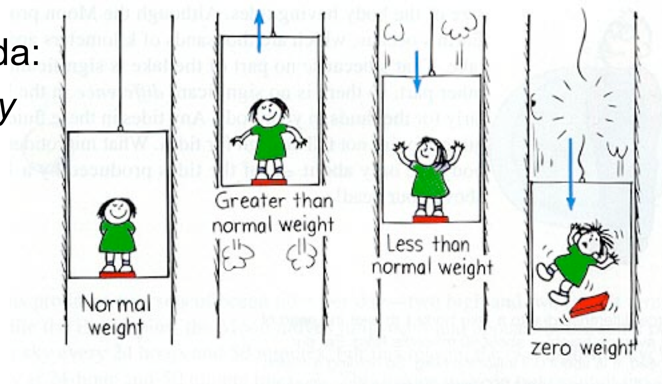
Welcome back to Physics 215!

Today's agenda:

- *Force Body Diagrams*
- *Weight*
- *Friction*



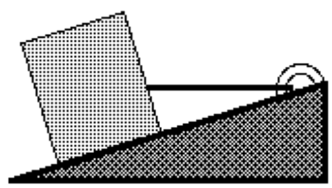
Reading for Thursday

- Newton's 3rd law and applications.
- More friction, drag, and circular motion
- OpenStax 5.5, 6.1, 6.3

Other forces

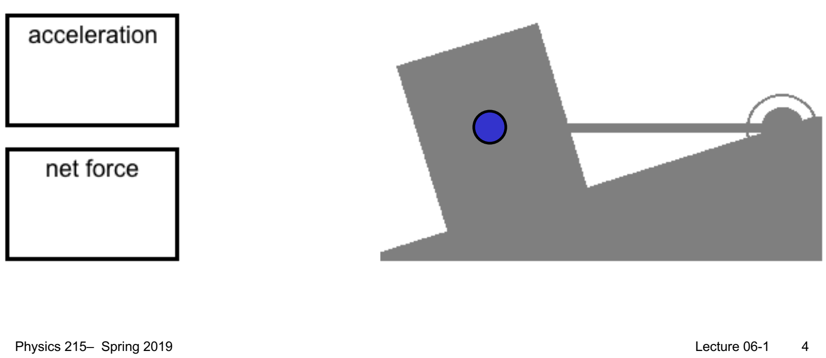
What is the tension in the string in terms of the block mass and angle of incline?

Besides normal force, what other forces are present for block on inclined plane?



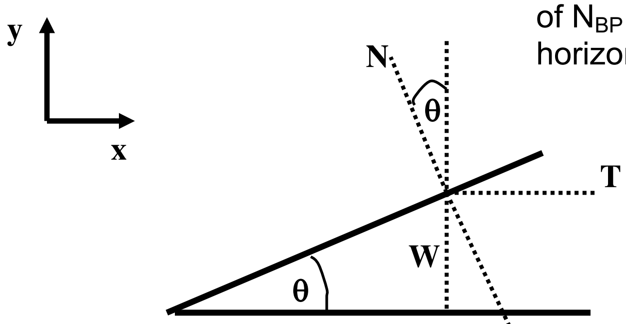
Free-body diagram: Block on frictionless incline

- Show all forces exerted *on* the block.
- Do *not* show forces exerted *by* the block on anything else.



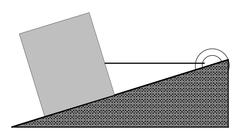
Geometry…

vertical component of N_{BP} is $N_{BP}\cos(\theta)$; horizontal is $N_{BP}\sin(\theta)$



Force components: Block on frictionless incline

F = 0 **implies all components of F are zero! Horizontal and vertical**



acceleration

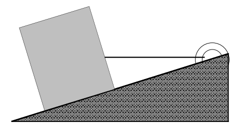
net force

Components of normal force

Components of weight force

Components of tension force

SG: When the block is held in place as shown, is the magnitude of the normal force exerted on the block by the incline



1. greater than the magnitude of the weight force (on the block by the Earth),
2. equal to the magnitude of the weight, or
3. less than the magnitude of the weight.
4. Can't tell.

Solving system

- *What is the tension in the string in terms of the block mass and angle of incline?*
- *Vertical* equilibrium:

$$N \cos(\theta) - W = 0$$

- *Horizontal* equilibrium:

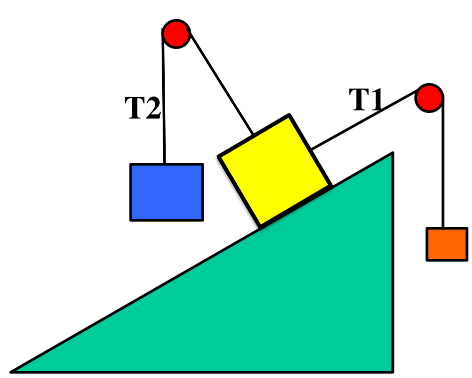
$$- N \sin(\theta) + T = 0$$

2 equations → solve for N and T in terms of W and θ

What have we learned?

- If at rest – net force = 0, since a = 0 !
- Write down FBD – identify all forces present
- Take force components in 2 (in 2D) directions to find unknowns
- Don't plug in numbers until end

Demo: bus on an inclined plane



SG: What is the smallest tension T2 that will make the bus lift up into the air?

A. The bus will be lifted if any tension T2 is applied ($T2 > 0$)
B. $T2 >$ weight on the bus $= W_{E\ on\ B}$
C. $T2 > W_{EB} \cos\theta$
D. $T2 > W_{EB} \sin\theta$

SG: What will happen to the bus if the incline suddenly collapses?

A. The bus will stay in exactly the same spot
B. The bus will fall straight down
C. The bus will move a little bit down and to the left
D. The bus will move a little bit up and to the right

Conclusion

- Normal forces can change when small changes are made to the situation.
- Can choose any 2 directions to find force components, but it pays to pick ones that simplify equations

Summary

- To solve problems in mechanics, identify all forces and draw free body diagrams for all objects
- If more than one object, use Newton's Third law to reduce number of independent forces
- Use Newton's Second law for all components of net force on each object
- Choose component directions to simplify equations

Weight, mass, and acceleration

- What does a bathroom scale ``weigh''?
- Does it depend on your frame of reference?
- Consider elevators….

Thinking about elevators…

- Y-axis: up is positive
- If an elevator is moving upward, then
  - if it speeds up the acceleration is _______
  - If it slows down the acceleration is ______
- If an elevator is moving downward
  - Speeding up: a   0
  - Slowing down: a   0

SG:
a) Draw a FBD for a person in an elevator who is accelerating downwards
b) Draw a FBD for a person in an elevator who is accelerating upwards
c) Draw a FBD for a person in an elevator moving at constant speed

pay special attention to the length of the vectors!

SG A person is standing on a bathroom scale while riding an express elevator upwards (towards the top) in a tall office building. When the elevator is at rest, the scale reads about 160 lbs.

While the elevator is moving, the reading is frequently changing, with values ranging anywhere from about 120 lbs to about 200 lbs.

At a moment when the scale shows the *maximum* reading (*i.e.,* 200 lbs) the elevator

A. Must be slowing down
B. Must be speeding up
C. could be slowing down or speeding up
D. I'm not sure.

Conclusions

- Scale reads magnitude of normal force $|N_{SP}|$
- Reading on scale does *not* depend on velocity
- Depends on acceleration *only*
  - * $a > 0 \rightarrow$ normal force bigger
  - * $a < 0 \rightarrow$ normal force smaller

"Weight": W_{EO}

- Free fall: only force acting is gravity
  - $a = g$
- From Newton's 2nd law, $a = F/m$
  - But $F = W_{EO}$ (gravitational force of earth on an object)
  - So $g = a =$
- In this class, when we say "weight" we usually mean "force due to gravity" = "force on a scale when at rest": $W_{EO} = mg$

Forces of friction

- There are two types of situations in which frictional forces occur:
  - Two objects "stick to each other" while at rest relative to one another ***(static friction)***.
  - Two objects "rub against each other" while moving relative to each other ***(kinetic friction)***.
- We will use a macroscopic description of friction that was obtained by experiment.

Friction demo

- Static friction: depends on surface and normal force for pulled block
- Kinetic friction: generally **less** than maximal static friction

The *maximum* magnitude of the **force of static friction** between two objects

- depends on the type of surfaces of the objects
- depends on the normal force that the objects exert on each other
- does **not** depend on the surface area where the two objects are touching

$$f_{B,T}^{\text{static}} \leq \mu^{\text{static}} N_{B,T}$$

The *actual* magnitude of the force of static friction is generally less than the maximum value.

SG A 2.4-kg block of wood is at rest on a concrete floor. (Using g = 10 m/s^2, its weight force is about 24 N.)

No other object is in contact with the block. If the coefficient of static friction is μ_s = 0.5, the frictional force on the block is:

A. 0 N

B. 8 N

C. 12 N

D. 24 N

SG A 2.4-kg block of wood is at rest on a concrete floor. (Using g = 10 m/s^2, its weight force is about 24 N.)

Somebody is pulling on a rope that is attached to the block, such that the rope is exerting a horizontal force of 8 N on the block. If the coefficient of static friction is μ_s = 0.5, the frictional force on the block is:

A. 0 N

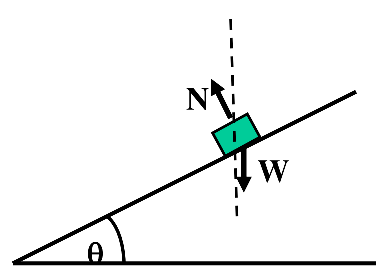
B. 8 N

C. 12 N

D. 24 N

SG A block is sitting at rest on an incline with friction. Which way does the friction force on the block point?

A. Down and to the left (along incline)
B. Up and to the right (along incline)
C. Straight left
D. Straight right



Sample problem: What is the largest angle before the block slips in terms of μ_s?