Physics 101

Prof. Ekey

Chapter 6

Dynamics along a line

(More Forces, Newton and Vectors)

Look back to chapter 3 & 5 for other examples

"In this chapter you will learn how to solve linear force-and-motion problems."

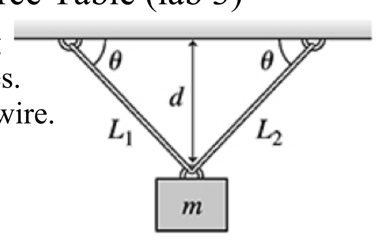
Static Equilibrium or Dynamic Equilibrium
object at rest moving with constant velocity

Equilibrium

Object on which the net force is zero (x & y coordinates also zero)

Static Examples: T-shirt tug-of-war (ch 3) or Force Table (lab 3)

A 20 kg loud speaker is suspended 2.0 m below the ceiling by two 3.0 m long cables that angle outward at equal angles. Determine the angle and equations for the tension in each wire.



Determine the net force in the x and y direction.

Solve for the overall tension in each cable.

Questions:

Which of the following objects is not in equilibrium (static or dynamic)?

(a) An out of gas car being pushed at constant speed
(b) A textbook held motionless in the hand of your outstretched arm
(c) A box in the back of a car that doesn't slide when it stops
(d) A hockey puck sliding across ice.

You push a cart from rest across a level floor with a small constant force. If you now push the cart with double the original force, what is a correct description of the carts subsequent motion? Ignore friction

(a) The cart moves with a constant speed that is bigger than the original speed.
(b) The speed of the cart is the same in either situation.
(c) The cart's speed increases to a constant value greater than the original.
(d) The cart moves with a continually increasing speed.

Force due to gravity… the weight of it all (again)

Gravitational attraction: Force of attraction between two masses.

$$F_{1\ on\ 2} = F_{2\ on\ 1} = \frac{Gm_1m_2}{r^2}$$

$G = 6.67 \times 10^{-11}\ Nm^2 / kg^2$ gravitational constant

We'll explore this in chapter 8 & 13

Free fall - only force acting on the masses is the force due to gravity.

$F_G = m \cdot g$ (note this is the magnitude, you choose direction)

gravity is smrt - Double the mass, you double the force due to gravity.

Flat-earth: "g" the same for motion within ~10 km of surface of earth

Weight (w) is a measurement, *the result of weighing an object.*
If standing on a stationary scale, your measured weight is F_G

$$\vec{F}_{net} = \vec{F}_{sp} + \vec{F}_G = 0 \qquad F_{sp} = mg$$

$w = mg$ Stationary object only

Mass is not weight – but they are related by "g" On earth 1 kg is 2.2 lb.

$$?N = 200\ lb\left(\frac{4.45\ N}{1\ lb}\right) = 890\ N \qquad m = \frac{F}{g} = \frac{890\ N}{9.8\ \frac{m}{s^2}} = 90.8\ kg$$

Elevator Action

Net force, anyone?

A 75.0 kg person is standing on a scale in an elevator, what is the reading on the scale (in Newtons) if the elevator is at rest?

Moving at a constant velocity?

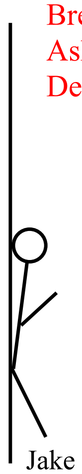
Accelerating up at 2.00 m/s^2

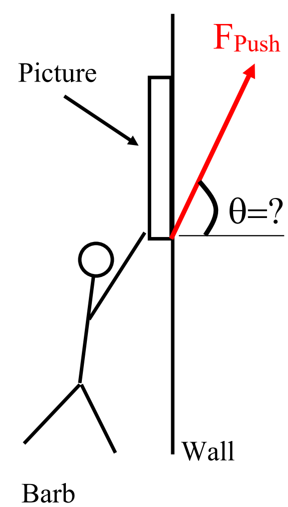
When accelerating upwards, the upward normal force exerted by the elevator on the person is ______ the downward weight of the person?

Forces at angles.

Jake and Barb are hanging a big picture (m=25 kg) on the wall. Barb holds the picture on the wall motionless as Jake decides whether or not they should hang it there. Barb pushes on the picture with a force of 300 N at an angle. For the picture not to move, what does the angle of the push have to be? Assume no friction.

Draw in all forces acting on the system
Break up Barb's push into x and y components.
Ask yourself which direction can the picture move?
Determine the net force?





Friction = Yes?

"ever-present resistance to motion that occurs whenever two objects/materials/media are in contact with each other."

Three flavors of friction:

Static - prevents relative motion between two objects
Sliding/Kinetic – resistance while in motion
Rolling – characterizes how wheels/balls grip surface (no slip)

Magnitude of Frictional force depends on… See Table 6.1
interaction between surfaces – coefficient of friction, μ
normal/support pushing the objects together - n

Force of static friction (max)

$$f_{s\ \text{max}} = \mu_s n$$

"slipping condition"

f_s can be less than the max, if the object remains stationary for a given push.

Ex: If you push a box with 50N, then 100N and it still doesn't move, the net force is still zero for the system

Force of kinetic friction

$$f_k = \mu_k n$$

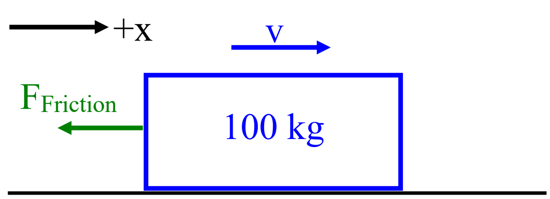
In general μ_k is less than the μ_s which means $F_{static} \geq F_{kinetic}$

Force of Rolling Friction

$$f_r = \mu_r n$$

We'll deal with this later

Box sliding across the floor



The coefficient of kinetic friction between the wooden box and the wood floor is 0.40. If the box is initially traveling with a velocity of 5.0 m/s, how long does it take to stop?

What's the net force on the box in the x & y direction?

Calculate the normal force

Calculate the kinetic friction force of the sliding box

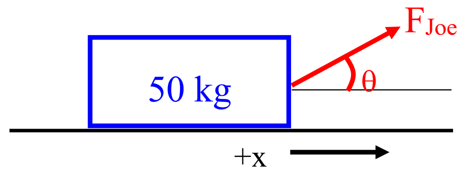
Determine the boxes acceleration

Use kinematic equations to find the stop time.

Friction for movers, possibly shakers.

Joe is sliding a 50 kg box across the floor and the box is moving with a constant velocity. Joe is pulling with a 30N force, at an angle of 30º above the horizontal. What are the kinetic friction force, and the coefficient of kinetic friction?

Draw in the rest of the forces acting on the system
Break Joe's Pull into X/Y components
Use net force in x-dir to find the friction force
Use net force in the y-dir to find force normal
Use the definition of friction to find the coefficient



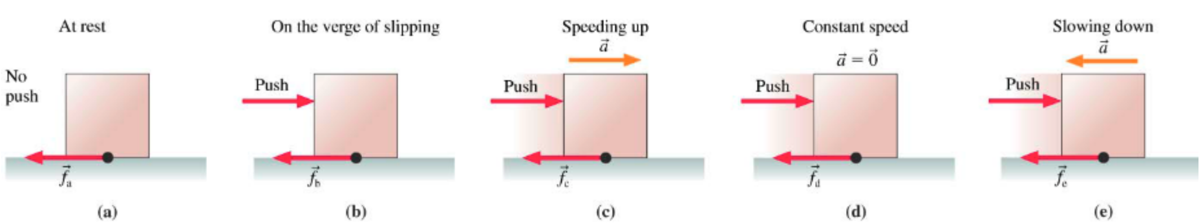
Questions

You are pushing a wooden crate across the floor at a constant speed. You decide to turn the crate on end, reducing by half the surface area in contact with the floor. In the new orientation, to push the same crate across the same floor with the same speed, the force you apply must be about…

(a) four times as great
(b) twice as great
(c) equally great
(d) half as great
(e) one-fourth as great

as the force required before you changed the crate's orientation.

Rank in order, from largest to smallest, the sizes of the friction forces (a-e) in these 5 different situations. The box and floor are made of the same material



Drag, D   Units: N

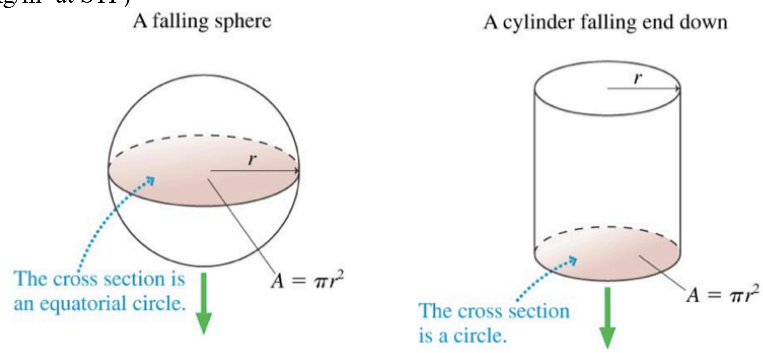
The air exerts a drag force on objects as they move through the air.
- Acts in the opposite direction of the velocity vector
- Increases in magnitude as the object's speed increases.

"simple model" (this is quite complicated)
- Assume object is moving through air near the earth's surface
- The object's size is between a few millimeters and meters
- The object's speed is less than a few hundred meters per second

$$\vec{D} = \tfrac{1}{2} C \rho A v^2, \text{ direction opposite the motion}$$

A = Cross sectional area of the object that faces the "wind"
ρ = is the density of air (1.2 kg/m^3 at STP)
C = Drag coefficient

Will never ask you a calculation question about this on a test. Maybe a concept question

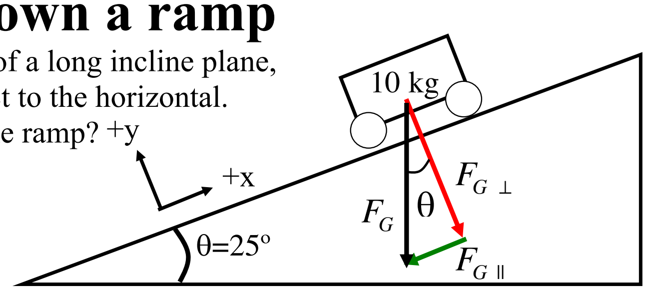


Assume no friction

Cart accelerating down a ramp

A cart of mass 10 kg is set at the top of a long incline plane, which has an angle of 25º with respect to the horizontal. What's the carts acceleration down the ramp?

Net force parallel to the ramp?



Net force perpendicular to the ramp?
Direction of the normal force?

Acceleration down the ramp?

How fast is the cart going at the bottom of the ramp?
Assume it has traveled 1.3 meters

What if we included friction?

θ=25º, m=10 kg

eMotionless box on an incline

A box sits motionless on an incline plane. If you were to tap the box in the negative x-direction, it would start sliding down the incline. Before this occurs, sketch this situation and draw a force diagram.

What is the magnitude and direction of the force of friction between the motionless box and the incline?

What is the magnitude and direction of the normal force on the box?

What is the coefficient of static friction?

Questions

A block pushed along the floor with velocity, *v*, slides a distance, d, after the pushing force is removed. What initial velocity is necessary, if you want the block to travel a distance of 2d before stopping?

(a) $2v$
(b) $\frac{1}{2}v$
(c) $\frac{1}{4}v$
(d) $\sqrt{2}v$

What is the acceleration of the block?

A block is sliding up and down a ramp and there is friction.
When is the net force parallel to the ramp the greatest?

(a) When sliding up the ramp
(b) At the turn-around point
(c) When sliding down the ramp
(d) The net force is the same throughout the motion.

I'd draw a diagram or two… three?