Friction (and sundry)

Physics 211
Syracuse University, Physics 211 Spring 2015
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February 12, 2015

Announcements

- Homework 4 should be posted today
- Another *Mastering Physics* assignment should be posted today (due Tuesday before class)
- Another *Mastering Physics* assignment should be posted today (due next Thursday before class)
- Read Chapter 8 for Thursday (don't worry if you don't understand everything – *yet!*)

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- Late MP submissions accepted for the previous MP assignment until end of day (I'll fix it)

Ask a Physicist: Special relativity

"Suppose for a moment that the universe was infinitely large with nearly an infinite amount of mass. Now, suppose all that mass was put into two objects at an incredibly far distance away. Now, due to gravity these objects begin to accelerate towards each other at a rate that would resemble earth's gravity for trillions of years. Is the maximum speed these objects will reach be the speed of light? If so, does this mean that gravity is relative to the speed of light?"

Ask a Physicist: Special relativity

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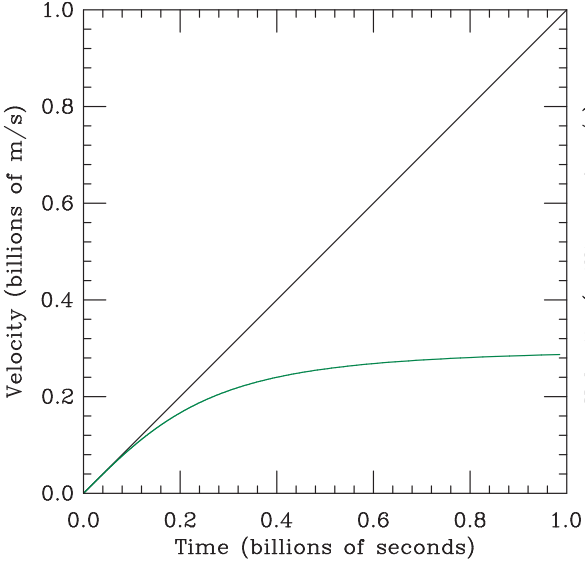
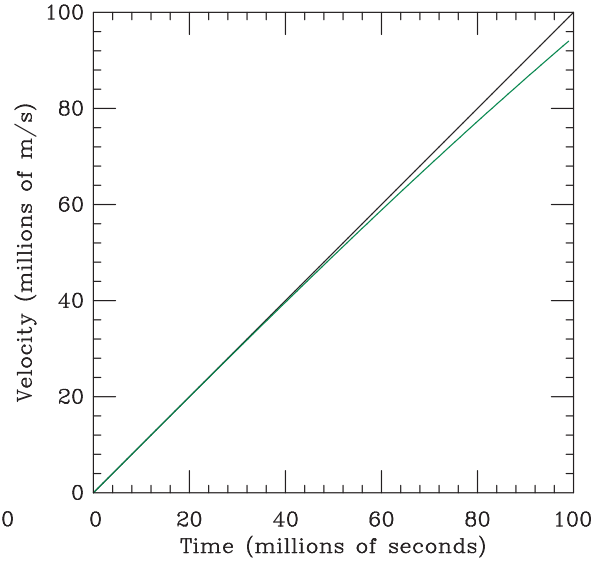


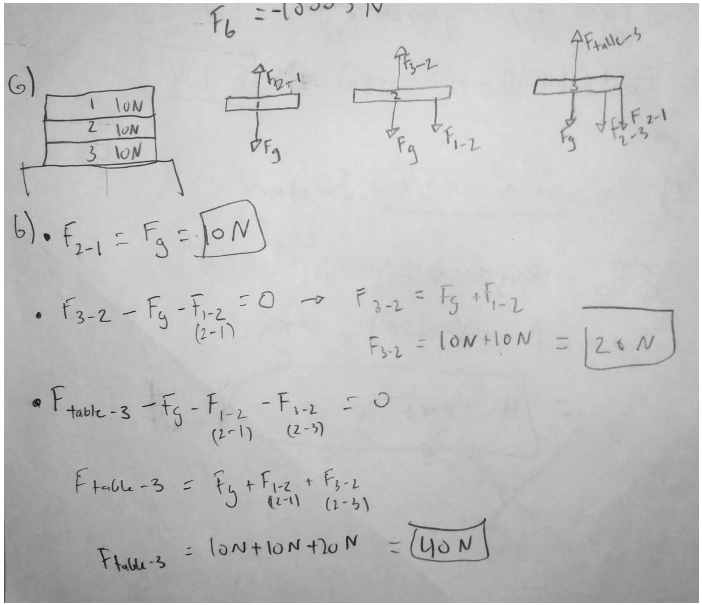


Homework review: Problem 1

- Only two forces: normal force of the ground on her feet, and her weight

$$\sum F = ma$$
$$F_N - mg = ma$$
$$F_N = mg + ma$$

Homework review: Problem 6



A new force: Friction

- Friction: stops two surfaces from sliding past each other
- Can either make things move or make things stop; opposes *relative* motion
- Two types:
  - Static friction: keeps two things that aren't sliding stuck together
  - Kinetic friction: opposes the relative motion of two things sliding

Coulomb's friction model

Friction is really complicated!

- Depends on details of surfaces, molecular forces, etc.
- No way to create a completely accurate general principle

There are a few general principles, though:

- Friction is higher if the normal force is higher
- Kinetic friction doesn't depend that much on the speed of travel

Simple model: often pretty close

- Friction depends on a property of the surfaces called the coefficient of friction μ
- Force of kinetic friction $= \mu_k F_N$
- Max force of static friction $= \mu_s F_N$

Coefficients of friction

TABLE 6.1 Coefficients of friction

Materials	Static μ_s	Kinetic μ_k	Rolling μ_r
Rubber on concrete	1.00	0.80	0.02
Steel on steel (dry)	0.80	0.60	0.002
Steel on steel (lubricated)	0.10	0.05	
Wood on wood	0.50	0.20	
Wood on snow	0.12	0.06	
Ice on ice	0.10	0.03	

A discussion of rolling

"Rolling without slipping":

- Neither static friction nor kinetic friction opposes rolling
- Point of contact doesn't slide (wheels work well!)
- Some residual loss of energy from "rolling friction" (flexing of the wheel)
- Static friction required to *keep* an object rolling without slipping sometimes

Problem solving: friction

Friction links the x and y directions:

- Friction acts parallel to the surface (appears in $\sum F_x = ma_x$
- Friction *depends* on the normal force, perpendicular to the surface (appears in $\sum F_y = ma_y$

This doesn't change how you should solve problems!

- Accounting: Draw force diagrams for every object (friction and normal force appear)

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- Kinematics: Connect acceleration to motion

Sample questions

A cart slides down a track elevated at angle θ with μ_k known; what is its acceleration?

Sample questions

Two masses of 20 and 40 kg hang from a massless pulley on either side. How do they move?

Sample questions

Two masses of m_1 and m_2 kg hang from a massless pulley on either side. How do they move?

Sample questions

A cart with mass m on a track is connected by a rope to a hanging weight of mass M. The coefficient of friction is μ. What is the acceleration of both objects?