Announcements

- The second midterm exam is March 8, 5-7 PM in White B51 (this room).
- The makeup exam is March 5, 5-7 PM in Clark 317.
- All exam info, including this, is at the class webpage, http://community.wvu.edu/~stmcwilliams/Sean_McWilliams/SP19_PHYS_101.html
- The exam will cover what we covered in class and was listed in the syllabus, from chapters 5 - 6, including all material through Monday's class.
- The questions will be multiple choice.
- Formula sheets will again be provided.

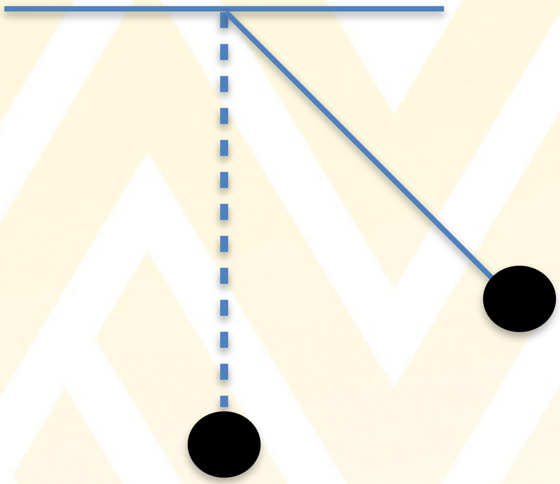
Today's lecture

Review of chapters 5 and 6

Example problem: Conservation of energy

A ball is attached to a pendulum. The ball is initially held at rest at a height of 30 cm above the floor. Then, the pendulum is allowed to oscillate. Neglect friction.

What is the ball's velocity at the lowest point of its trajectory?



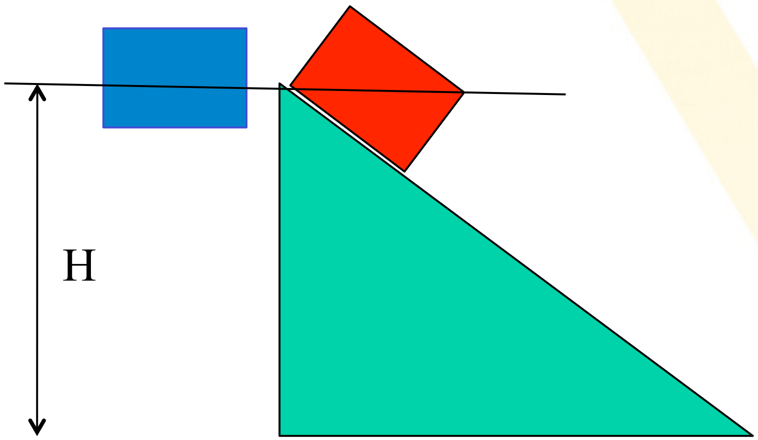
$$\frac{m}{2}v_1^2 + mgh_1 = \frac{m}{2}v_2^2 + mgh_2$$

Example problem: Conservation of energy

A rollercoaster car is at the top of a hill. If its speed at the top of the hill is 2.0 m/s, calculate the speed ignoring friction at the point *P* shown below:

Non-conservative forces

Two identical boxes fall a distance H. One falls directly down; the other slides down a frictionless incline. Which has the larger speed at the bottom?



A. The one falling vertically

B. The one sliding down the incline

C. Impossible to determine

D. It's the same

$$W_{nc} = (KE_f - KE_i) + (PE_{gf} - PE_{gi})$$

No non-conservative forces: $$\frac{1}{2}mv_i^2 + mgy_i = \frac{1}{2}mv_f^2 + mgy_f$$

What, if we turn friction back on?

Example problem: Springs

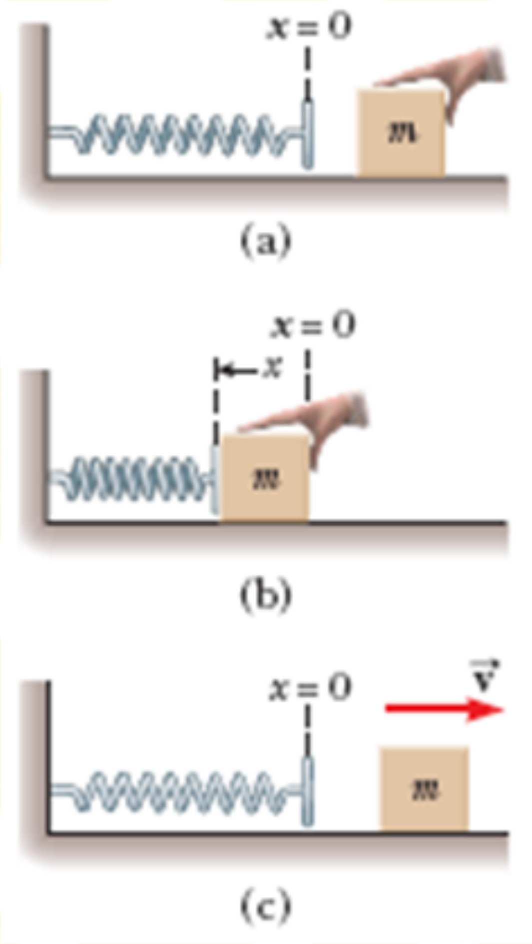
A spring attached to a wall has a spring constant (k) of 850 N/m.

A block of mass 1.00 kg is attached to the spring and oscillates freely on a horizontal, frictionless surface as in the figure below.

(a) Find the energy stored in the spring when the mass is compressed 6.00 cm from equilibrium.

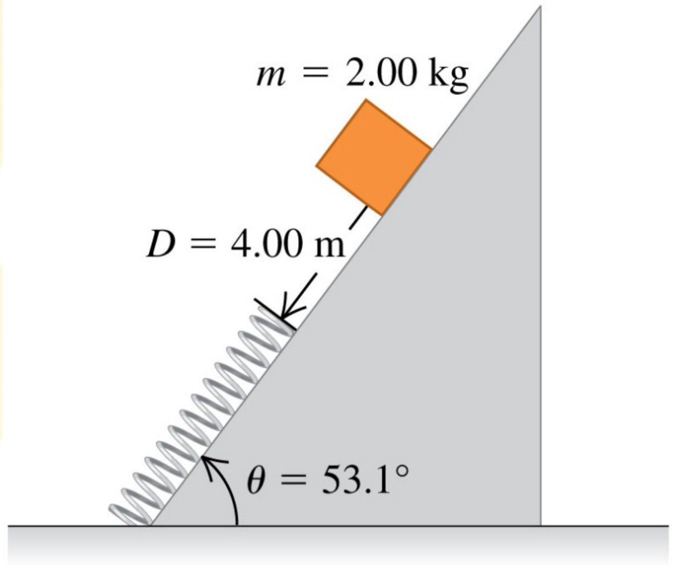
(b) Write the conservation of energy equation and solve it for the speed of the mass as it passes equilibrium.

(c) What is the speed at the halfway point?



Energy conservation

A block is released from rest on a frictionless incline as shown. When the moving block is in contact with the spring and compressing it, what is happening to the gravitational potential energy PE_g and the spring potential energy PE_s?



A. PE_g and PE_s are both increasing.

B. PE_g and PE_s are both decreasing.

C. PE_g is increasing; PE_s is decreasing.

D. PE_g is decreasing; PE_s is increasing.

E. The answer depends on how the block's speed is changing.

$$PE_g = mgy$$

$$PE_s = \frac{1}{2}kx^2$$

Energy conservation: $\rightarrow (KE + PE_g + PE_s)_i = (KE + PE_g + PE_s)_f$

How much does the Flash have to eat?

$$KE = \tfrac{1}{2} m v^2$$

The Flash's (and our) caloric intake requirements increase quadratically the faster we run. Twice as fast means four times the calories needed to fuel the running.

Let's say Flash's mass is 70 kg (155 pounds) and he is running at 1 % the speed of light ($v = 3 \cdot 10^6$ m/s).

$$\rightarrow \quad KE = \frac{1}{2} \cdot 70\,kg \cdot (3 \cdot 10^6\, m/s)^2 = 3.15 \cdot 10^{14}\, J$$

How many calories is this? - 1 calorie = 4184 J.

KE = 75 billion calories!

That's about 150 million burger!

Example problem: Power

A bicyclist coasts down a 7.0^{o} hill at a steady speed of 5.0 m/s. Assuming a total mass of 75 kg (bicycle plus rider).

What must be the cyclist's power output to climb the same hill at the same speed?

Example problem: Horsepower

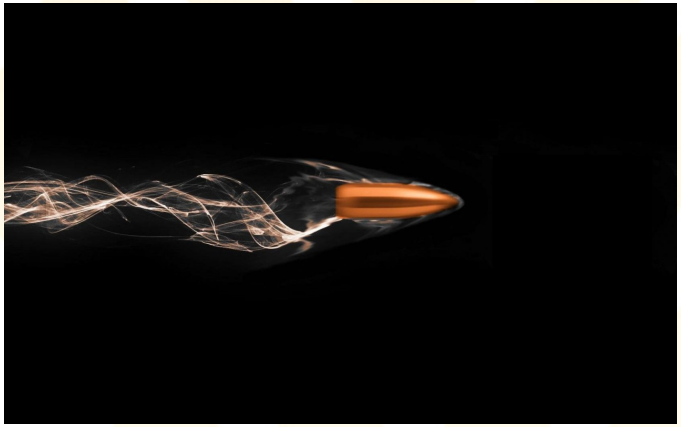
An advertisement claims that a certain 1200 kg car can accelerate from rest to a speed of 25 m/s in a time of 8.0 s. What power (in units of horsepower) must the motor produce in order to cause this acceleration?

Ignore losses due to friction. (1 hp=746 W)

Example problem: Linear momentum

A pitcher claims he can throw a 0.145 kg baseball with as much momentum as a 3.00 g bullet moving with a speed of 1500 m/s!

What must the baseball's speed be if the pitcher's claim is valid?



The pitcher must throw a 0.145 kg baseball at 31 m/s in order to make sure that it has the same momentum as a 3 g bullet moving at 1500 m/s.

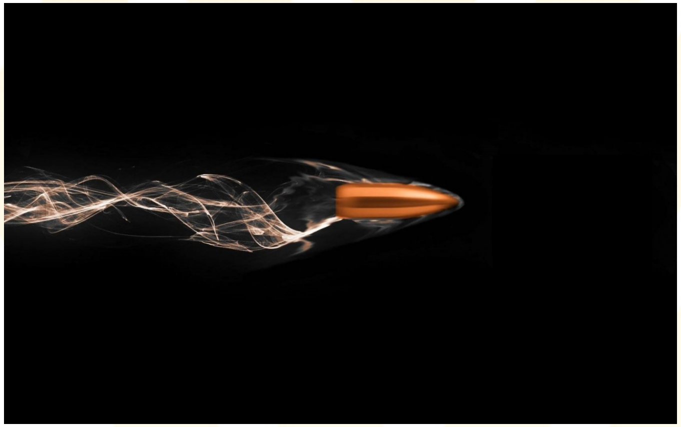
Which object has the greater kinetic energy?

$$\vec{p} = m\vec{v}$$

A. The ball

B. The bullet

C. They are the same



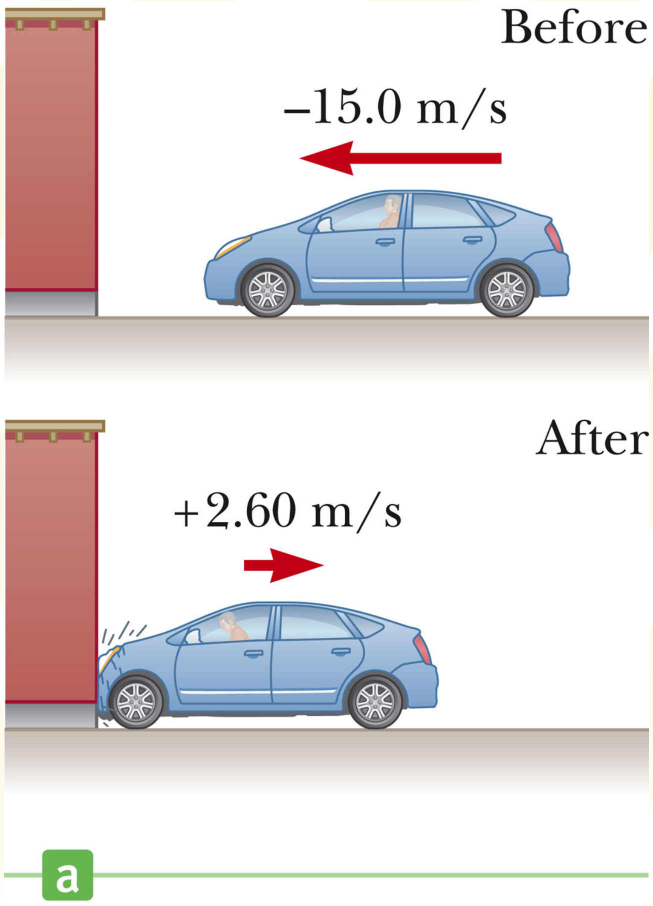
Example problem: Car crash

In a crash test, a car of mass 1500 kg collides with a wall and rebounds as shown in the figure. The initial and final velocities of the car are v_i = -15 m/s and v_f = 2.6 m/s, respectively. If the collision lasts for 0.15 s, find

A. the impulse delivered to the car due to the collision.

B. the size and direction of the average force exerted on the car.

$$\vec{I} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = \vec{F}_{net} \cdot \Delta t$$



Impulse

A 100-g lump of clay hits a wall at 70 cm/s and sticks.
A 100-g rubber ball hits the same wall at 60 cm/s and rebounds with a speed of 30 cm/s.

Which object experiences the larger impulse delivered by the wall during the collision?

A. The clay

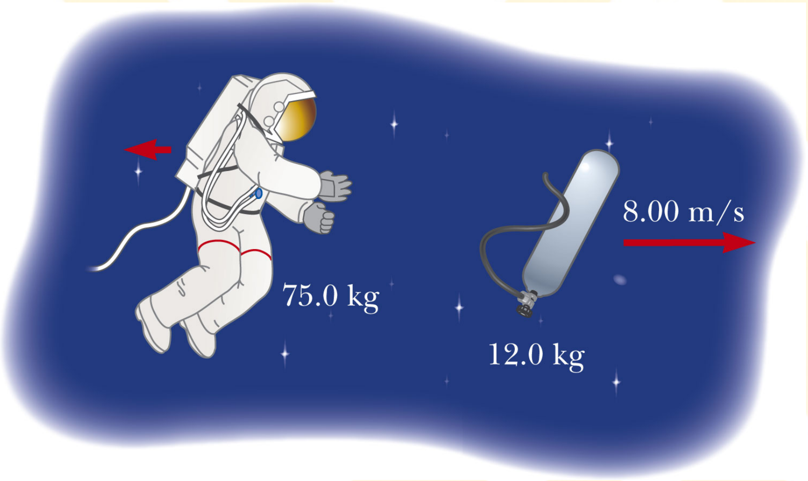
B. The ball

C. Both impulses are the same.

D. Cannot be determined.

$$\vec{I} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i = \vec{F}_{net} \cdot \Delta t$$

Example problem: Astronaut in space



An astronaut in his/her space suit has a total mass of 87 kg, including suit and oxygen tank. His/her tether line loses its attachment to her spacecraft, while he/she is on a spacewalk. Initially at rest with respect to her spacecraft, she throws her 12 kg oxygen tank away from her spacecraft with a speed of 8 m/s to propel herself back toward it.

Determine the maximum distance she can be from the craft and still return within 2 min (the amount of time the air inside her helmet remains breathable).

Example problem: Elastic collisions

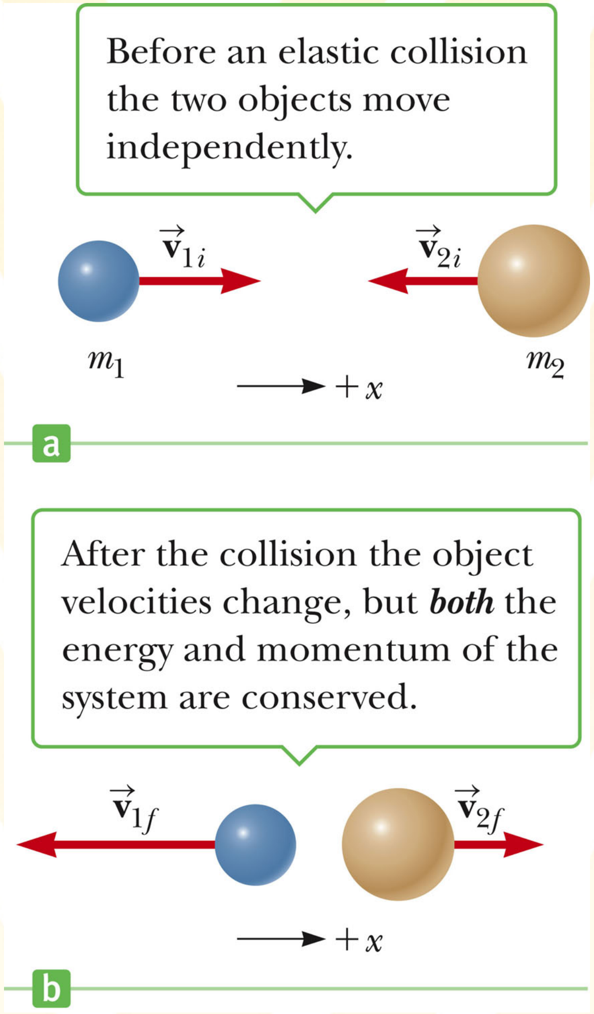
A 25 g object moving to the right at 0.2 m/s collides elastically with a 10 g object moving in the same direction at 0.15 m/s.

Find the velocity of each object after the collision.

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$
$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

Typical situation: 2 unknowns and 2 equations

Recipe: Solve one equation for one unknown and substitute the result into the other equation.

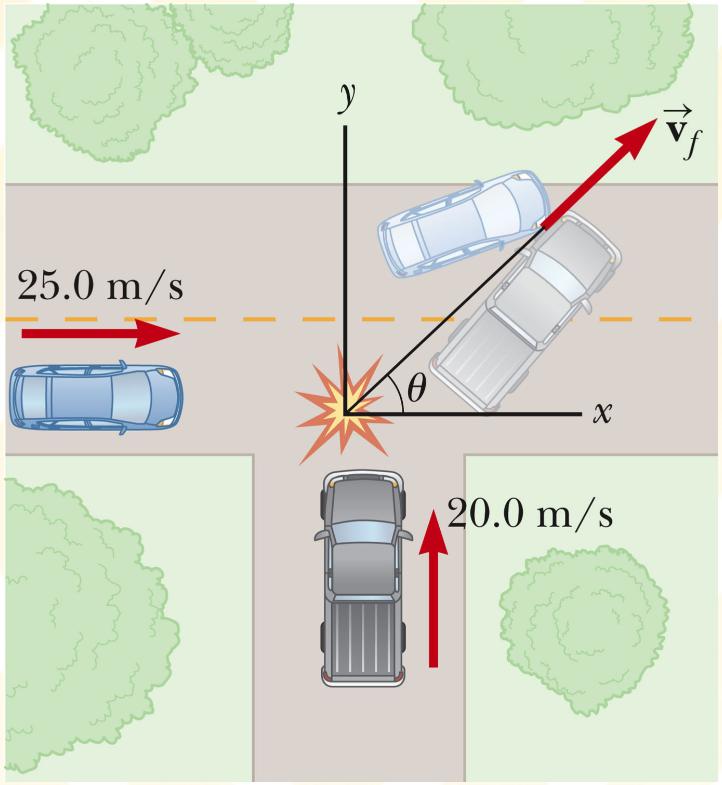


Example problem: Collision at an Intersection

A car with mass 1500 kg traveling east at a speed of 25 m/s collides at an intersection with a 2500 kg van traveling north at a speed of 20 m/s. After the collisions both cars stick together and the resulting wreckage propagates at a common speed.

Find the magnitude and the direction of of the velocity of the wreckage.

Neglect Friction, i.e. any external forces.



Example Problem: Rocket propulsion

A rocket has a total mass of 1×10^5 kg and a burnout mass of 1×10^4 kg, including engines, shell, and payload. The rocket blasts off from earth and exhausts all its fuel in 4 min, burning the fuel at a steady rate with an exhaust velocity of 4.5×10^3 m/s.

(a) If air, friction, and gravity are neglected, what is the speed of the rocket at burnout?

(b) What thrust does the engine develop at liftoff?