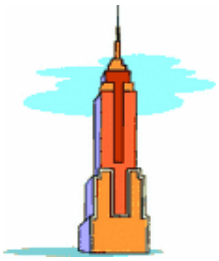
Announcements

1. No homework due tomorrow, light HW for Sat

2. **Exam 2 starts today!**
   a. Exam begins Tues Oct 7, 10:15 am
   b. Exam ends Mon Oct 13, end of day
      i. Late fee if you pick up your exam after 5 pm
   c. Covers Chapters 4 & 5, Homeworks 4-8
      i. But potentially cumulative questions
   d. **3 hour time limit** like last time
   e. **Last year's exam** posted on website
      i. Work out exam before looking at solutions
      ii. Students took an average of 2.0 hours
      iii. Average score was 65%
      iv. I attempted to make this year's exam 2 a little easier
   f. **Format**
      i. Mostly the same as your exam 1
      ii. There will be at least one (maybe 2 or 3) problems where you turn in work
         1. Example: "Draw free body diagram…"

   g. **Note card** like last time
      i. 3×5 note card, front & back, handwritten only
      ii. I will not give you formulas on the exam
      iii. I *will* give any constants (like g = 9.8 m/s^2) or conversion factors that you need.
   h. **Calculators allowed** like last time
   i. **Things to study** like last time
      i. HW problems
      ii. In-class problems (clicker quizzes & problems)
      iii. Last year's exam
      iv. Warmup questions
      v. Concepts from lectures & demos
      vi. Etc.

Power (continued from last lecture)



Empire state building:
Height: 1,250 feet, 443 meters
Stories: 102
There are 1,575 steps from the building's lobby to the 86th floor (374 m). Paul Crake holds the record for racing these steps in 10 minutes, 15 seconds.

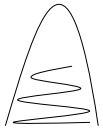
What average power did he expend against gravity?
(Assume m=80 kg)

From work:

From velocity:

Switchbacks on mountain roads

(consider only work done against gravity)



Clicker quiz:
a. They increase the work needed to go up a mountain
b. They decrease the work needed to go up a mountain
c. They keep the work needed the same

Clicker quiz:
a. They increase the power needed to go up a mountain
b. They decrease the power needed to go up a mountain
c. They keep the power the same

Formulas Review

Definitions and Fundamental Laws
Final exam: you will be expected to know these

Newton's 2nd Law: $\sum \vec{F} = m\vec{a}$
Newton's 3rd Law: $\vec{F}_{12} = -\vec{F}_{21}$
Work: $W = F_{//}\,\Delta x = F\cos\theta\,\Delta x$
Kinetic Energy: $KE = ½\, m\, v^2$
Conservation of energy: $E_{before} + W_{net} = E_{after}$
Power: $P = \Delta E/\Delta t$

"Bag of tricks"
Final exam: I will give you these

Gravity: $w = mg$, $PE_g = mgy$
Springs: $F = -kx$, $PE_s = ½\, kx^2$
Friction: $f = \mu N$ (or $f \le \mu N$, for static friction)

Miscellaneous
Final exam: I will give you this

$P = F \cdot v$

Concepts Review

1. Newton's Laws of Motion
   a. 1st Law: inertia
   b. 2nd Law: $\sum \vec{F} = m\vec{a}$
      i. True for each object, as well as for groups
      ii. True for both x- and y-components
   c. 3rd Law: partner forces, equal & opposite
      i. Act on different objects

2. Forces
   a. unit: Newtons
   b. free-body diagrams
   c. weight = mg
      i. don't need to know "Universal Gravitation" yet
   d. Normal force
   e. friction: $f = \mu N$ (or $f \le \mu N$, for static friction)
   f. tension
   g. pulleys
   h. spring: $F = -kx$

3. Work done by a force, on an object
   a. $W = F_{//}\,\Delta x = F\cos\theta\,\Delta x$
      i. unit: Joules

4. Energy
   a. unit: Joules
   b. Kinetic: $KE = ½\, m\, v^2$
   c. Gravity: $PE_g = mgy$
      i. don't need to know "Universal Gravitation" yet
   d. Springs: $PE_s = ½\, kx^2$
   e. **Conserved!!** $E_{before} + W_{net} = E_{after}$
      i. "before" and "after" pictures
      ii. include both PE and KE in "E" terms
      iii. include all nonconservative forces in W
         1. work occurs "during" the change
         2. positive and negative work

5. Power
   a. Definition: $P = \Delta E/\Delta t$
      i. unit: Watts
   b. Power from velocity: $P = F \cdot v$

Dr Colton: "How to solve Newton's 2nd Law Problems" (Posted to the Google group a while ago to help people understand the "Chris problem")

1. Draw free-body diagrams for each object.
1b. Divide forces into components if necessary.
1c. Group objects together if it seems convenient.

2. Use the Newton's 2nd Law "blueprint equation" to get a "real equation" for each object.
2b. Do this for each direction if necessary.

3. Plug what you know into the equations, and look at what results.

4. Solve the equations for what you're looking for.
4b. Sometimes this involves solving simultaneous eqns.

Some HW problems (missed by many):

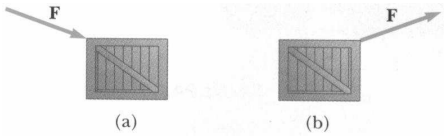
HW 6 Problem 2

Chris wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected to a rope that passes over a frictionless pulley (see figure), Chris pulls on the loose end of the rope with such a force that the spring scale reads 275 N. Chris's true weight is 327 N, and the chair weighs 168 N. Find Chris's upward acceleration and the force Chris exerts on the chair.

Answers: 1.09 m/s^2; 88.3 N

HW 6 Problem 5

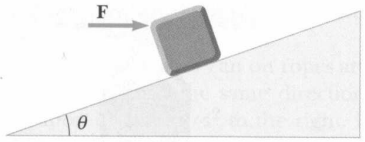
A 1410 N crate is being pushed across a level floor at a constant speed by a force F of 312 N at an angle of 23.7° below the horizontal as shown in Figure (a). (a) What is the coefficient of kinetic friction between the crate and the floor? (b) Next suppose the 312-N force is instead pulling the block at an angle of 23.7° above the horizontal as shown in Figure (b). What will be the acceleration of the crate now?



Answers: 0.186; 0.324 m/s^2

HW 7 Problem 1

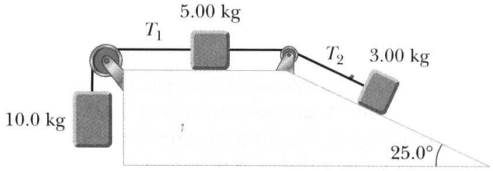
A 2.00-kg block is held in equilibrium on an incline of angle 51.4° by a horizontal force F. The coefficient of static friction between the block and incline is $\mu_s = 0.334$. Determine the minimum value of F and the normal force of the incline on the block.



Answers: 12.7 N; 22.1 N

HW 7 Problem 2

The three blocks of masses 10.0 kg, 5.0 kg, and 3.0 kg are connected by light strings that pass over frictionless pulleys as shown in the figure. The acceleration of the 5.00-kg block is 2.41 m/s^2 to the left and the surfaces are rough. Find the tensions T_1 and T_2, and the coefficient of kinetic friction between blocks and surfaces.



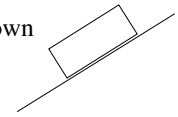
Answers: 73.9 N; 34.5 N; 0.558

More conceptual quizzes

Clicker quiz: A hammer hits a nail, and the nail is driven into the board. The magnitude of the force of the nail on the hammer is _____ the force of the hammer on the nail.

a. less than
b. the same as
c. more than

Clicker quiz: A box of weight *mg* is sliding down a frictionless inclined plane. The work done by the normal force is:



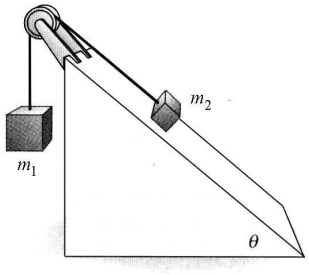
a. equal to the work done by gravity
b. equal to the *negative* of the work done by gravity
c. equal to the kinetic energy gained
d. equal to the *negative* of the kinetic energy gained
e. zero

Clicker quiz:
The amount of potential energy possessed by an elevated object is equal to:

a. the distance it is lifted
b. the force needed to lift it
c. the work done in lifting it
d. the value of the acceleration of gravity

More worked problems

Two objects are connected by a light string that passes over a frictionless pulley as in the figure. One object lies on a smooth incline. In the figure, $m_1 = 9.39$ kg, $m_2 = 4.56$ kg, and $\theta = 44.6°$ Find (a) the magnitude of the acceleration of the objects and (b) the tension in the string.

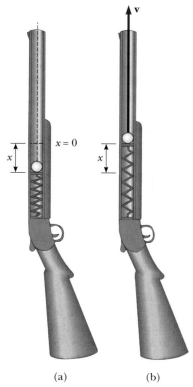


Answers: 4.347 m/s^2, 51.204 N

A box of books weighing 287 N is shoved across the floor of an apartment by a force of 424 N exerted downward at an angle of 34.7° below the horizontal. If the coefficient of kinetic friction between the box and floor is 0.571, how long does it take to move the box 4.00 m, starting from rest?

Answer: 2.235 s

A toy gun has a spring of unknown spring constant. If the spring is compressed a distance of 0.127 m and the gun fired vertically as shown, the gun can launch a 20.3-g projectile from rest to a maximum height of 17.7 m above the starting point of the projectile shown in Fig. (a). Neglecting friction, determine the spring constant and the speed of the projectile as it moves through the equilibrium position of the spring (where x = 0 in the figure).



Answers: 436.634 N/m, 18.626 m/s

A 20.3-kg child on a 2.26-m-long swing is released from rest when the swing supports make an angle of 33.1° with the vertical. (a) If no friction, find the child's speed at the lowest position. (b) If the speed of the child at the lowest position is 1.51 m/s, what is the mechanical energy lost due to friction?

Answers: 2.681 m/s, 49.828 J