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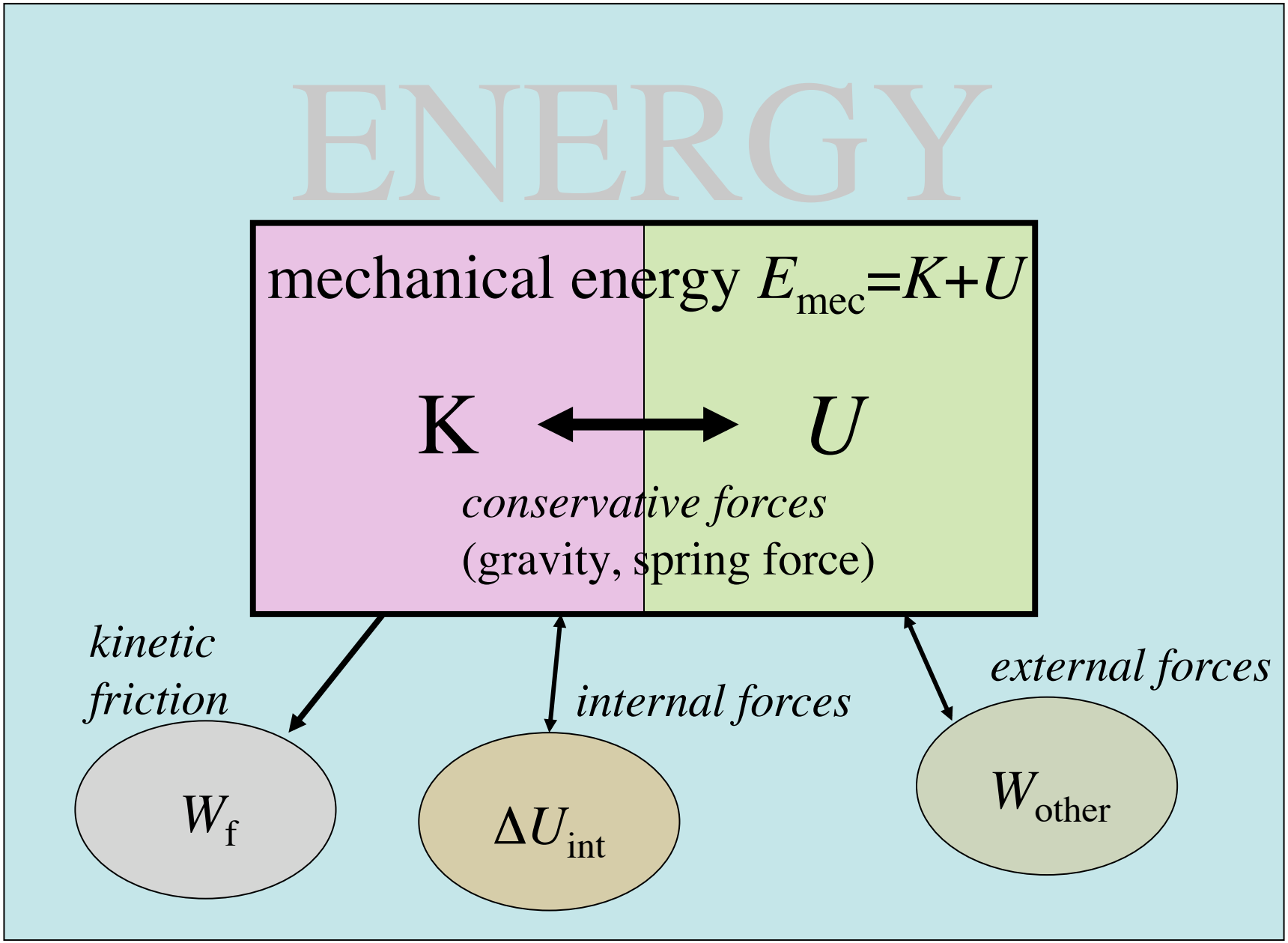
Bad logic -
What equation do I use?

Good logic -
What information do I know?
What information am I being asked to find?
What key ideas/conceptual tools do I apply?
What equations express these ideas?


ENERGY
mechanical energy $E_{mec}=K+U$
K
U
conservative forces
(gravity, spring force)
kinetic friction
internal forces
external forces
W_f
ΔU_{int}
W_{other}

Some tips to remember:

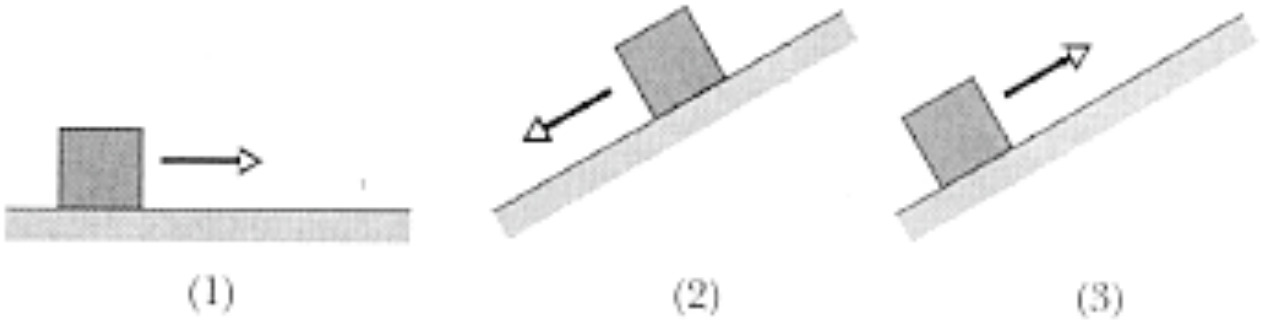
- Kinetic energy is always positive while potential energy and work can be either positive or negative. Use your intuition and the work-KE theorem to keep track of signs.

- Momentum is always conserved during collisions between isolated bodies. The total kinetic energy is not always conserved, but the center-of-mass kinetic energy and center-of-mass velocity are always conserved.

- Viewed in the center-of-mass frame, the collision of any two bodies reduces to a head-on encounter of the objects, each one having equal and opposite momentum to the other.

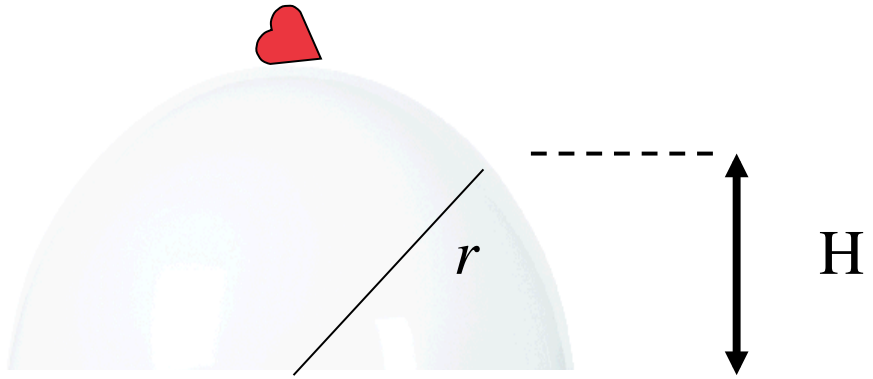
A few more tips:

- Symmetry arguments can help constrain the center of mass location of objects with uniform density.
- The center of mass of an object does not have be located within the physical boundaries of the object itself.
- The location where “half the mass is above and half below” is not necessarily the vertical position of the center of mass.



A block slides on a surface with friction oriented in the three possible ways shown above. The arrow shows the sign of the velocity. For which case(s) will the kinetic energy of the block decrease with time?

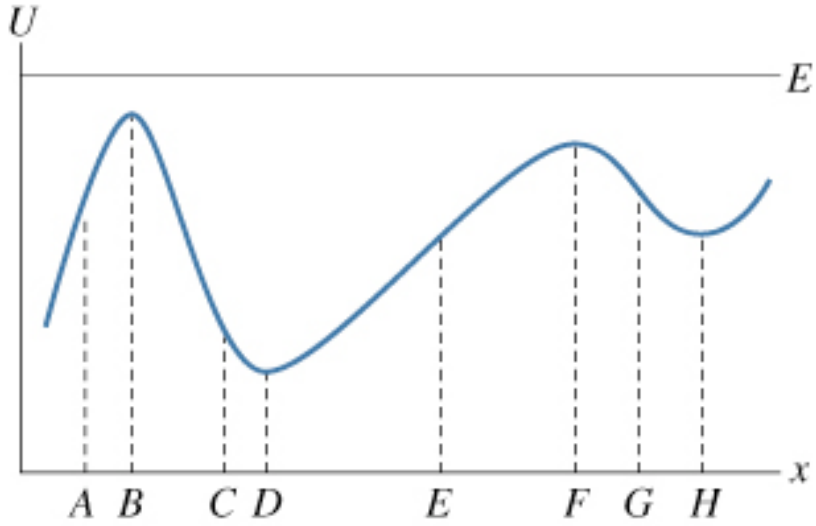
1)
2)
3)
4) both 1) and 3)
5) both 1), 3) and possibly 2).



A frozen strawberry sits atop a hemispherical mound of ice of radius *r*. It is given a nudge that sends it sliding along the frictionless surface. At some height H it loses contact with the surface of the ice and moves in projectile motion thereafter. To calculate the height H, which concepts will you need to apply?

1. conservation of mechanical energy
2. circular motion
3. Newton's second law
4. impulse
5. All of 1-3
6. All of 1-4

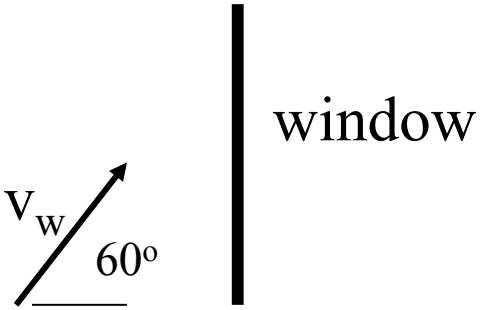
The curve at right shows the potential energy curve of a particular experimental setup. How many locations of stable equilibrium exist in the interval shown?



1. 1
2. 2
3. 3
4. 4
5. 5
6. zero

Suppose the entire population of the world gathers on one island and, at the sounding of a prearranged signal, everyone jumps upward. During the brief moment when all the people are in the air, does the Earth gain momentum in the opposite direction?

1) Yes. Earth recoils, like a rifle firing a bullet, with a change in momentum equal to and opposite that of the people.
2) No. The mass of the earth is so large that the planet's motion is completely unaffected.
3) Yes. Because of its much larger mass, however, the change in momentum of the Earth is much less than that of all the jumping people.



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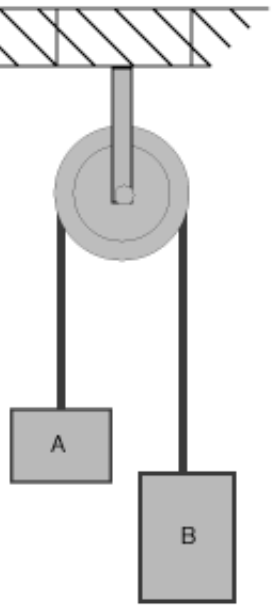
Firefighters are attempting to break a window using a stream of water flowing at a rate of 50kg/s. The water stream has a velocity v_w=30m/s oriented 60 degrees above horizontal when it hits the window. After impact, the water slides vertically downward. What is the horizontal force on the window due to the water?

1. 1500N
2. 750N
3. 500N
4. 250N
5. 75N

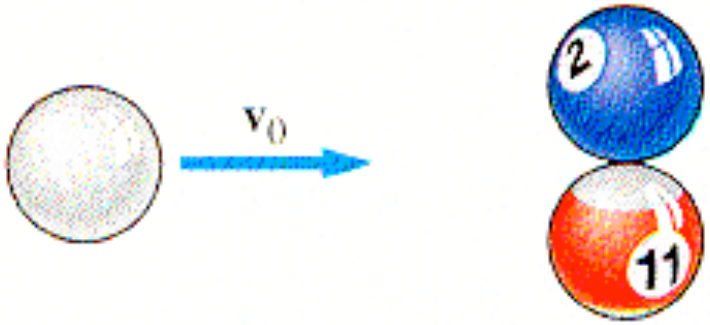
An Atwood's machine consists of two masses A and B, with A heavier than B, connected across a frictionless pulley by a light rope. What will be the behavior of the center of mass of the two-block system?



1. The center of mass position drops and center of mass speed increases.
2. The center of mass position stays the same and center of mass speed stays the same.
3. The center of mass position drops and center of mass speed stays the same.
4. The center of mass position stays the same and center of mass speed increases.

A uniform chain of length L is held initially at rest on a frictionless table with 1/4th of its length hanging over the edge. What is the speed of the chain just after the last link slides off the table?

1. $(gL/2)^{1/2}$
2. $(2gL/3)^{1/2}$
3. $(3gL/4)^{1/2}$
4. $(7gL/8)^{1/2}$
5. $(15gL/16)^{1/2}$



On a pool table, three identically-sized billiard balls collide elastically in the arrangement shown above. The cue ball hits the exact center of the 2/11 ball pair. At what angles with respect to the incident velocity v_0 will the 2/11 balls emerge?

1. 60 degrees up/down
2. 45 degrees up/down
3. 30 degrees up/down
4. 15 degrees up/down
5. 0 degrees

From a stationary start, is it possible for a rocket to accelerate up to a speed equal to the exhaust speed of its ejected fuel?

1. **sure, why not?**
2. **no way**
3. **maybe?**

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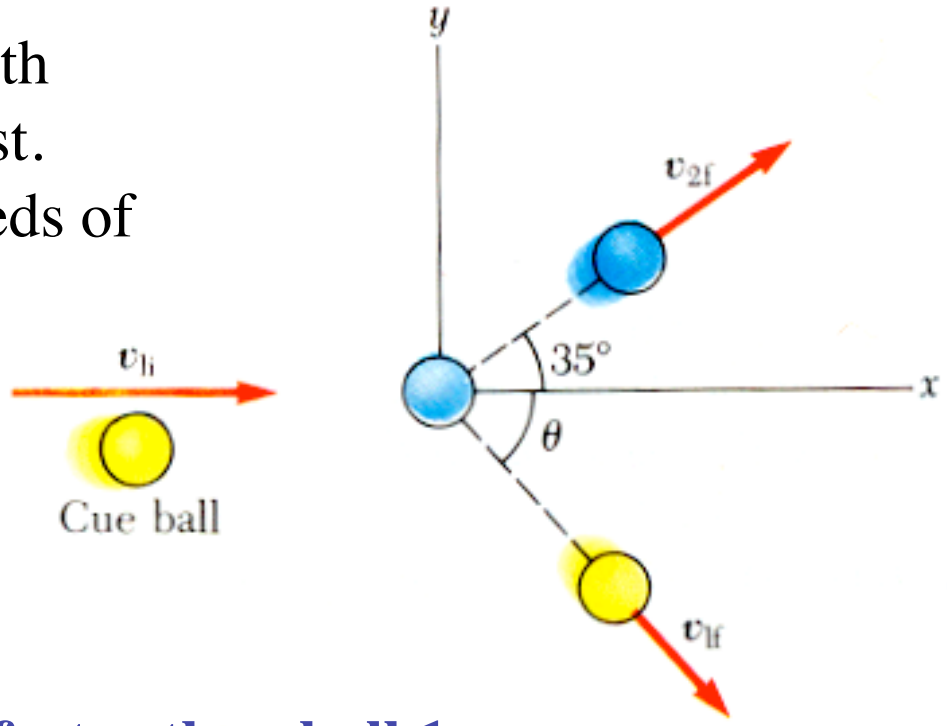
Chapter	Concepts	Calculations
6	3	3
7	3	4
8	3	4
total	9	11

A cue ball collides elastically with another (blue) ball initially at rest. What can you say about the speeds of the balls after the collision?



1) **ball 2 is moving faster than ball 1.**
2) **ball 2 is moving slower than ball 1.**
3) **the balls have equal speeds.**
4) **more information is needed.**

A ball of mass m dropped from initial height h hits the floor and rebounds to a height $0.9h$. What change in the ball's kinetic energy occurred during the collision with the floor?

1. **0**
2. **$0.1mgh$**
3. **$0.2mgh$**
4. **$-0.1mgh$**
5. **$-0.2mgh$**

You graduate and obtain gainful employment debugging video game software. The game you're working on involves a one-dimensional potential energy of the form

$$U(x) = -32/x + 15\,x^2$$

and your task is to compute the force $F(x)$ as a function of position. What is the answer?

1. $F(x) = 32/x + 30x$
2. $F(x) = -32/x^2 - 30x$
3. $F(x) = 32/x^2 + 5x$
4. $F(x) = 64/x^2 - 5x$
5. $F(x) = -64/x^2 - 30x$

You throw a marble with initial speed of 20 m/s from the top of Dennison into the (empty) courtyard below. Air drag on the marble is negligibly small and so can be ignored. To maximize the marble's kinetic energy on impact with the ground, in which direction should you throw it?

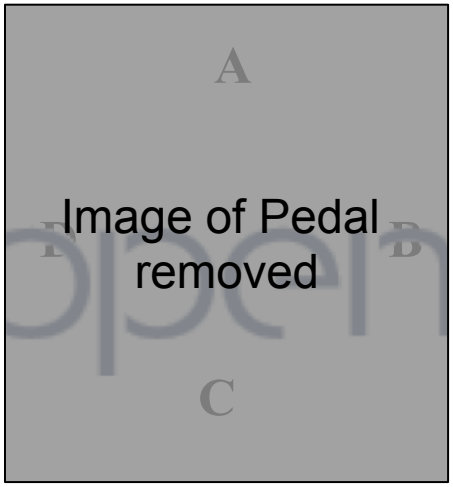
1. upward.
2. downward.
3. horizontally.
4. 45 degrees above horizontal.
5. It doesn't matter in which direction you throw it.

As you ride upward in an elevator at constant speed, the mechanical energy of the "you-Earth" system is

1) increasing.
2) decreasing.
3) staying constant.
4) any of the above, depending on the speed.

As you ride upward in an elevator at constant speed, the change in mechanical energy of the "you-Earth" system is provided by what force?

1) gravity
2) normal force of the floor on your feet
3) tension in the elevator cable
4) both 2) and 3)
5) all of 1), 2) and 3)

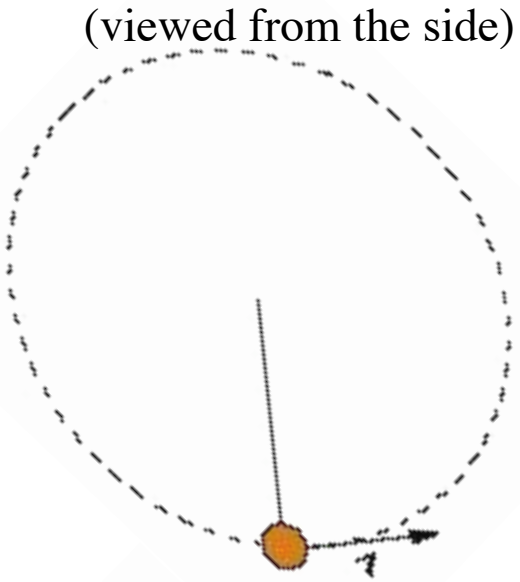
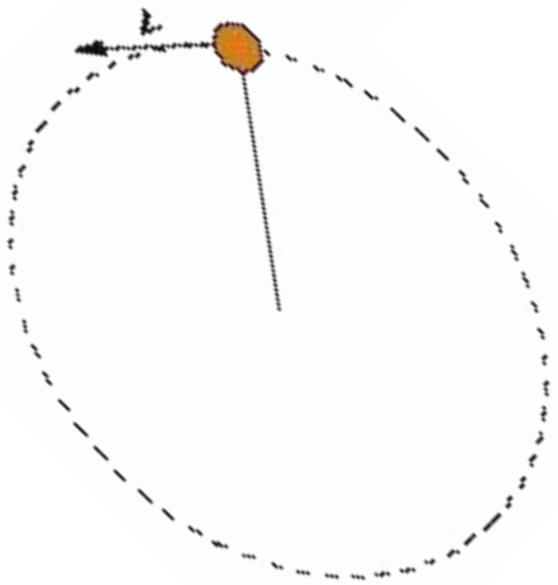


From "Training the Olympic Athlete"
by J. Kearney, Sci American, June 1996, p55.

The arrows in this graphic give the force exerted on the left pedal of a test bicycle by five-time Tour de France winner Lance Armstrong. Assuming that the pedal cadence is nearly constant, rank the points labeled by the power applied at those locations, **least to greatest**

1. **A, D, C, B**
2. **A, D, B, C**
3. **D, A, C, B**
4. **D, C, B, A**
5. **A, B, C, D**

A ball is whirled around in a *non-circular* orbit oriented vertically. The distance between top and bottom of the orbit is $2r$. If the ball's speed at the bottom and top of the orbit is the same, how much work is done by the string tension T while the ball makes half an orbit from the bottom to the top?



1. zero
2. $-2\pi Tr$
3. $-2mgr$
4. $2mgr$
5. $2\pi Tr$