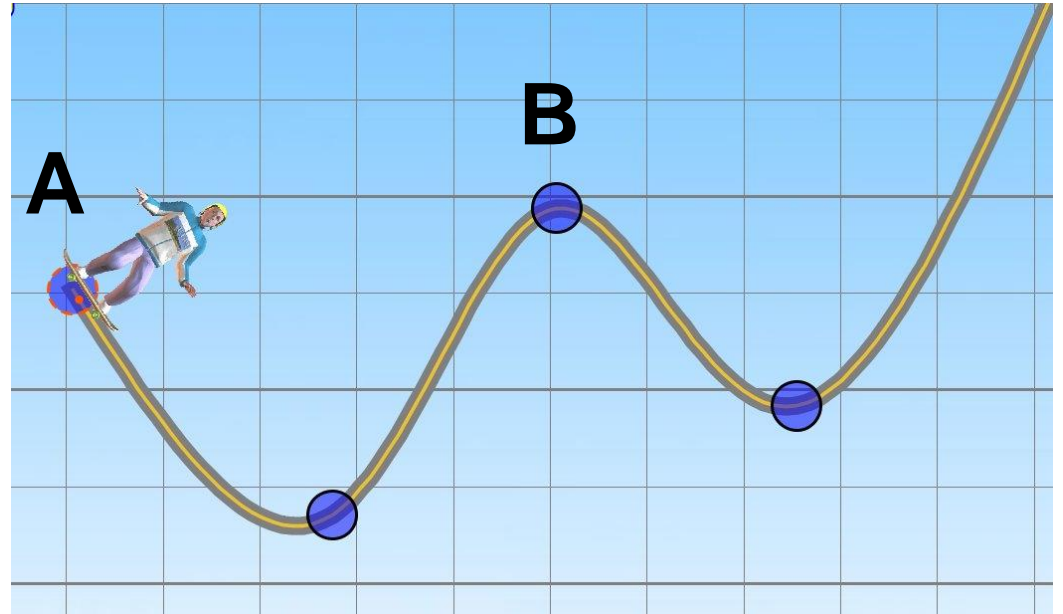# Physics
Conservation of Energy

Science and Mathematics Education Research Group

Skateboard Physics
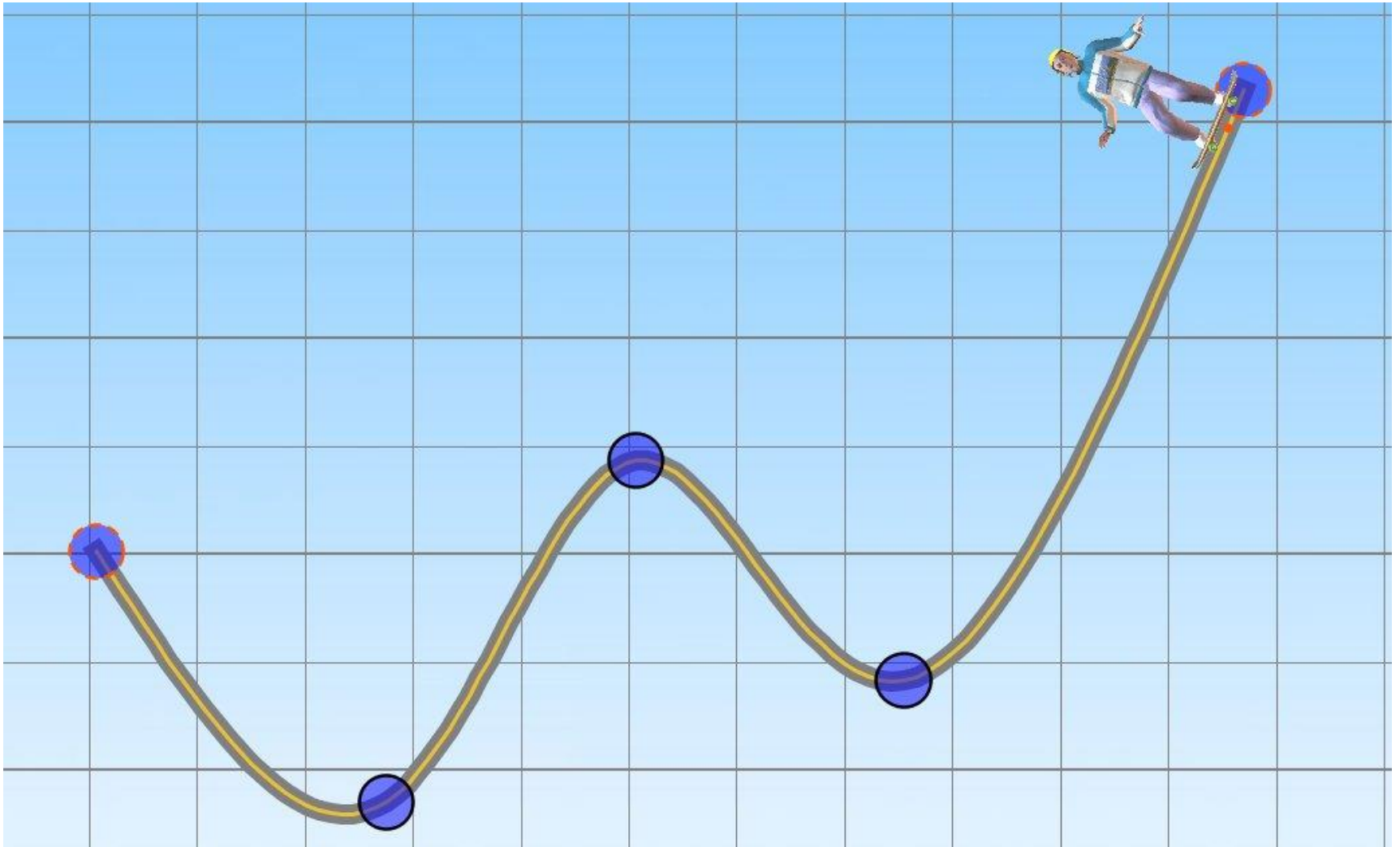
Skateboard Physics I

A skater starts at point A from rest. Will he be able to make it over point B? (Assume the track is frictionless)

A. No, because he doesn't have enough initial potential energy

B. No, because some of his potential energy will be converted to thermal energy

C. Yes, because he has enough initial potential energy

D. Yes, because the track is frictionless

Solution

Answer: A

Justification: At point A, all of the skater's energy is in the form of potential energy. Because energy can not be created, only transferred from one form to another, the skater will never have any more energy than at this point.

Along the path from A to B, no energy is converted to thermal energy since the track is assumed to be frictionless. If no energy is lost, the skater will have enough energy to reach the same height he started with.

Since point A is lower than point B, the skater will not be able to make it to point B.

Skateboard Physics II

A skater starts at point A from rest. Will he be able to make it over point B? (Assume the track is frictionless)
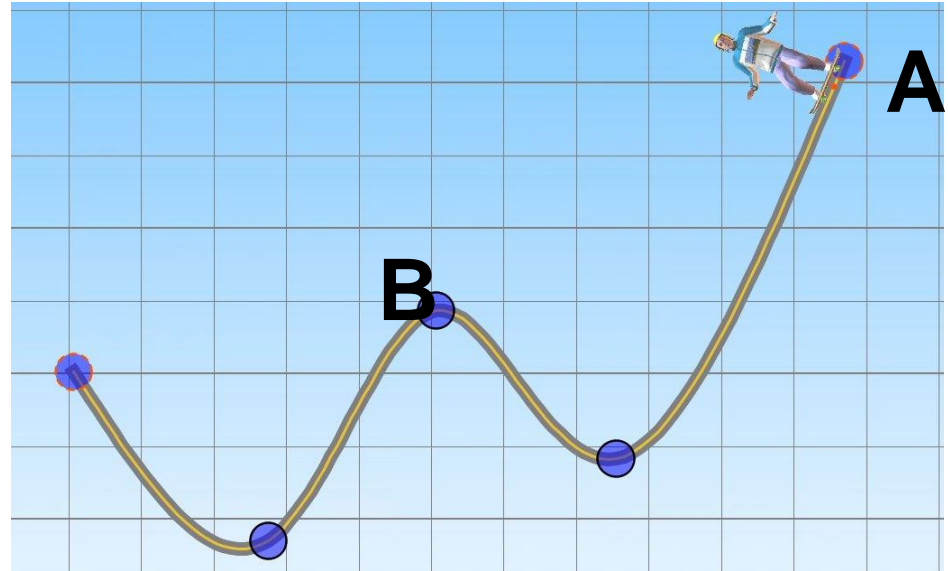
A. No, because he doesn't have enough initial potential energy

B. No, because some of his potential energy will be converted to thermal energy

C. Yes, because he has enough initial potential energy

D. Yes, because the track is frictionless

E. Both C and D
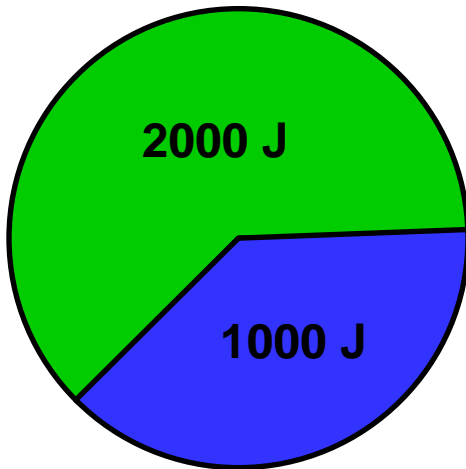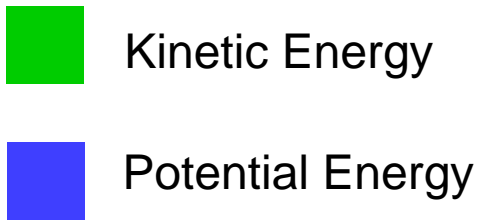
Solution

Answer: E

Justification: At the beginning the skater has only potential energy and no kinetic energy. This is the maximum amount of energy the skater will ever have.

Along the path from A to B, no energy is converted to thermal energy since the track is frictionless. If no energy is lost, the skater will have enough energy to reach the same height he started with.

Since point A is higher than point B, the skater will be able to make it to point B.

Skateboard Physics III

The skater at the position shown has 2000 J of **kinetic energy** and 1000 J of **potential energy**. In which direction is the skater moving?
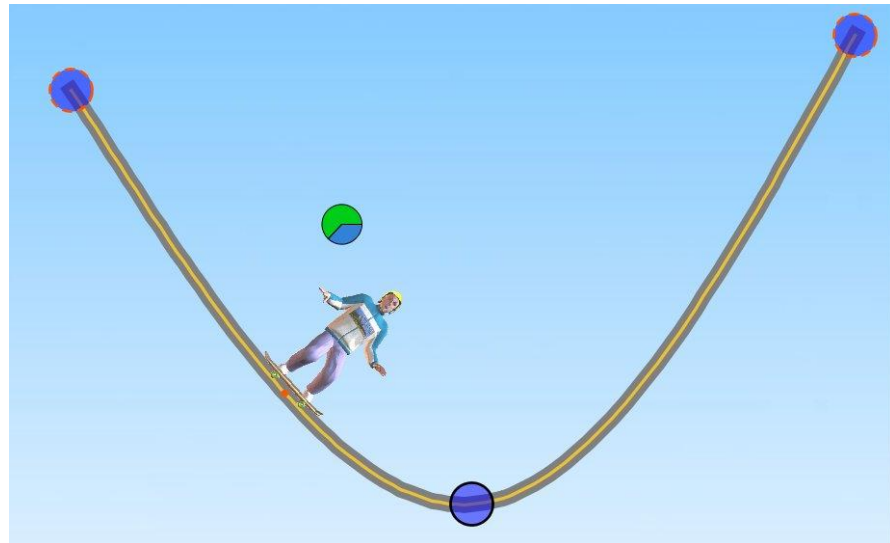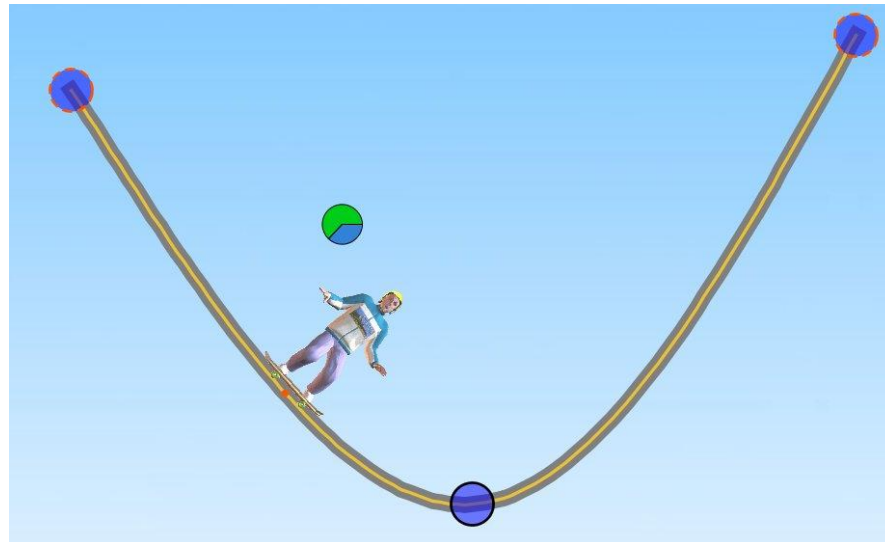
Kinetic Energy

Potential Energy

2000 J

1000 J

A. The skater is moving uphill (to the left)

B. The skater is moving downhill (to the right)

C. Not enough information

Solution

Answer: C

Justification: Energy is a scalar quantity and cannot tell us about the direction the skater is moving. The skater will have the same amount of kinetic and potential energy at the location shown when moving uphill or downhill.

Skateboard Physics IV

A moment later, the skater's **kinetic energy** _increases_ (the green slice of the pie graph gets larger). What happens to the skater's speed?
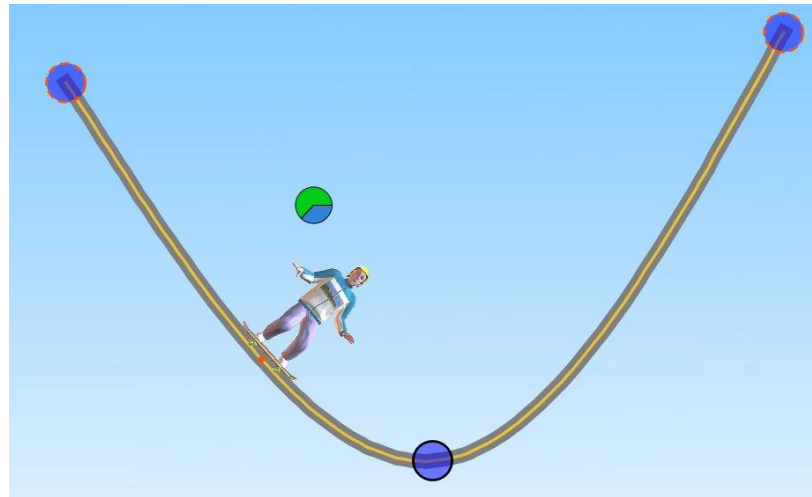

Kinetic Energy

Potential Energy
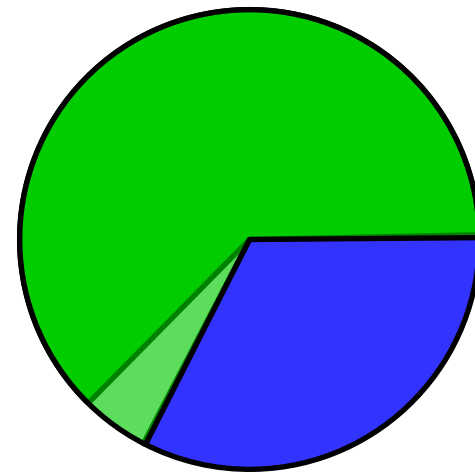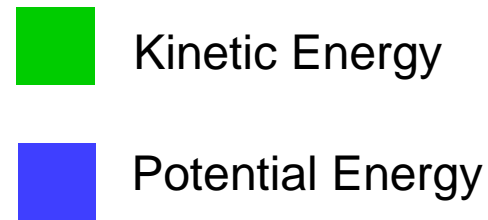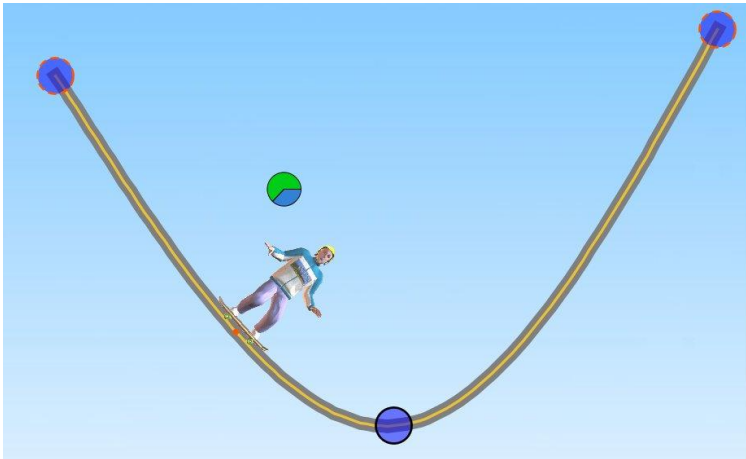
A. The skater will be moving faster

B. The skater's speed remains the same

C. The skater will be moving slower
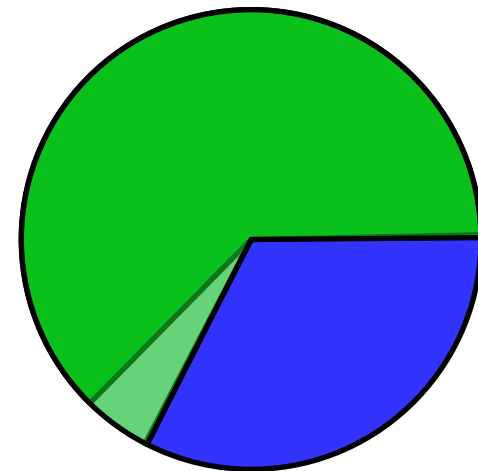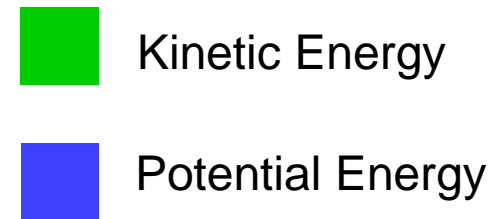
Solution
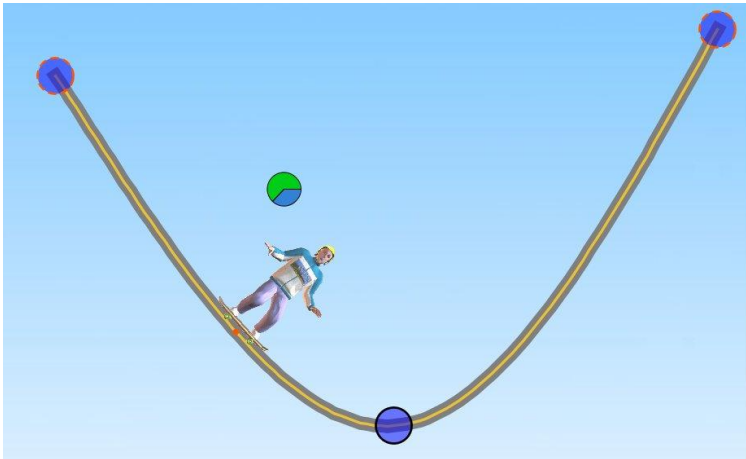
Answer: B

Justification: The equation for kinetic energy is $KE = \frac{1}{2}mv^2$,

where *v* represents speed (the magnitude of velocity). Because the mass of the skater does not change, the only way for the kinetic energy to change is if there is a change in speed. Kinetic energy is positively related to speed, so an increase in speed will result in an increase in kinetic energy.

Skateboard Physics V

A moment later, the skater's **kinetic energy** _increases_ (the green slice of the pie graph gets larger). In which direction is the skater moving?
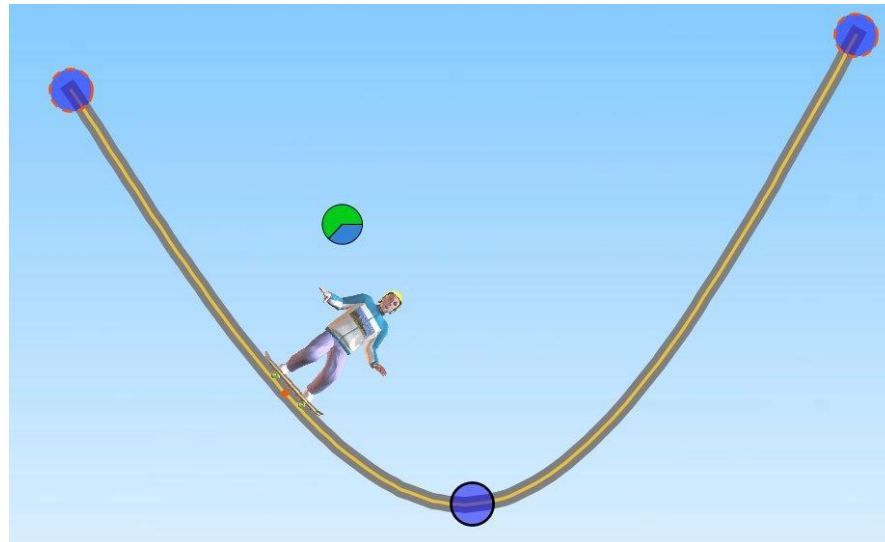

Kinetic Energy

Potential Energy

A. The skater is moving uphill (to the left)

B. The skater is moving downhill (to the right)

C. Not enough information

Solution

Answer: B

Justification: Due to the force of gravity, an object moving downhill speeds up, while an object moving uphill will slow down. Since the kinetic energy is increasing, the speed must be increasing as well, and the skater must moving down the slope, or to the right of the diagram.

Skateboard Physics VI

A moment later, the skater's **kinetic energy** _increases_ (the green slice of the pie graph gets larger). What happens to the potential energy?

Kinetic Energy
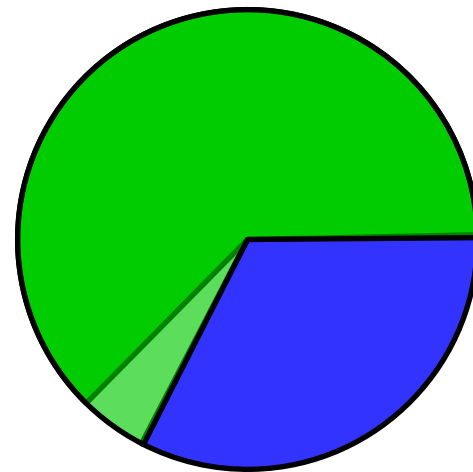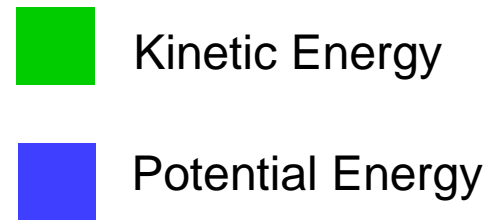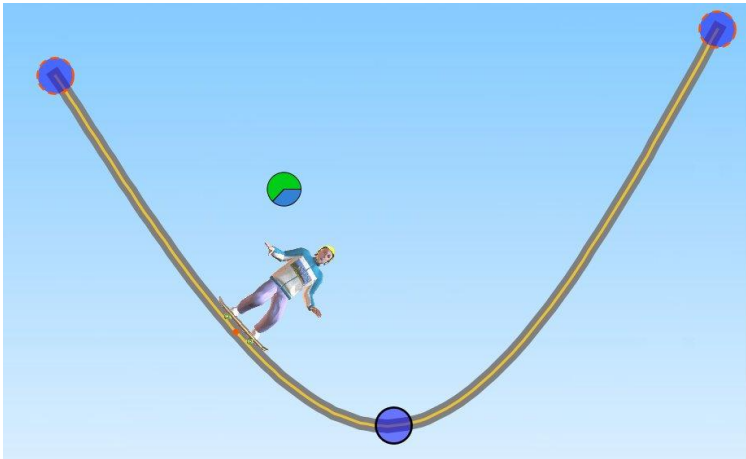
Potential Energy

A. The potential energy increases

B. The potential energy stays the same

C. The potential energy decreases

Solution

Answer: C

Justification: The amount of energy in a system is constant, and cannot be created or destroyed. If the kinetic energy is increasing, then the potential energy must decrease in order for the total amount of energy to remain the same.

Also, we know from question 5 that the skater is moving down the slope. This means that he is losing height. Potential energy is *mgh*, where *h* is the height of the object relatively to the chosen reference level (for example, ground). Since the height is decreasing, and his mass and the acceleration of gravity remain constant, the potential energy must also be decreasing.

Skateboard Physics VII

The skater started at point A from rest. The highlighted region on the chart shows the energy of the skater at t = 4.2 s. At which point on the track could the skater be located?
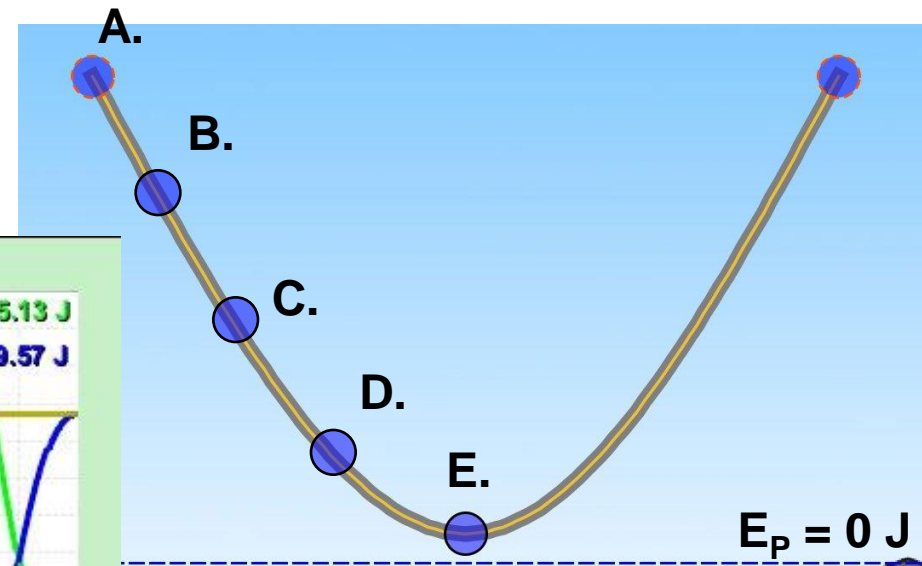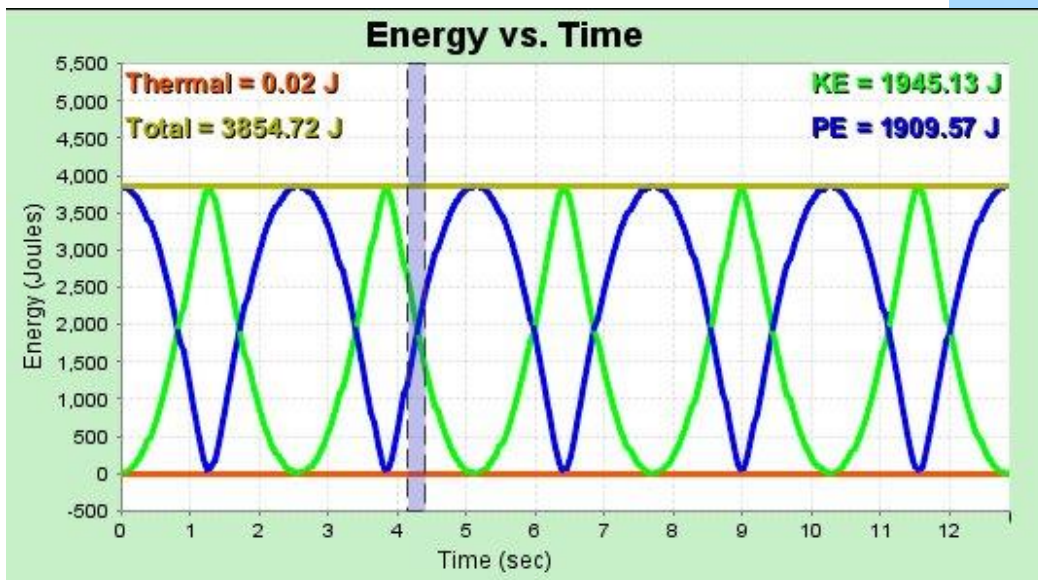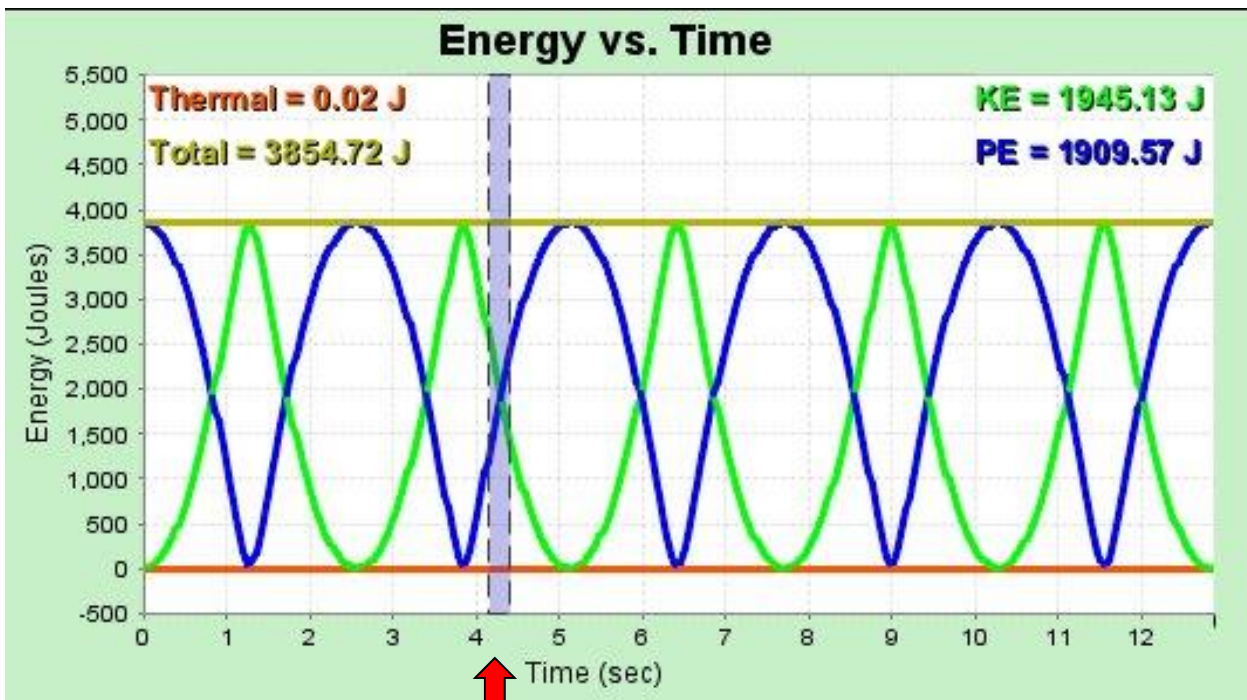
Solution

Answer: C

Justification: At the highlighted time on the graph, the potential energy of the skater accounts for approximately half of his total energy (the other half is in kinetic energy).

At the top of the graph the skater has only kinetic energy, and at the bottom the skater has only potential energy.

Since $E_P = mgh$, potential energy is proportional to height. The skater's potential energy is only half of his maximum potential energy, so the skater must be located at half the height of his initial position. Therefore, the skater should be located at point C.

Skateboard Physics VIII

Which direction is the skater moving at the highlighted time? (t = 4.2 s)

A. Uphill

B. Downhill

C. Cannot be determined

Solution

Answer: A

Justification: In the next moment, the skater's potential energy increases and his kinetic energy decreases. Potential energy is proportional to mass and gravity, which are constant. In order for potential energy to change the height of the skater must change. The potential energy is increasing, therefore his height must also be increasing.

Alternatively, the kinetic energy is decreasing. Kinetic energy is proportional to speed. In order for kinetic energy to decrease, speed must decrease. There are no forces other than gravity acting on the system, so the skater must be moving up the slope, and slowing down due to gravity.

Skateboard Physics IX

The skater started at point A from rest. The bar graph shows the energy of the skater at a later time. At which point on the track could the skater be located?

A.

B.

C.

D.

E.

$E_P = 0$ J

Energy (J)

Kinetic Potential Thermal Total
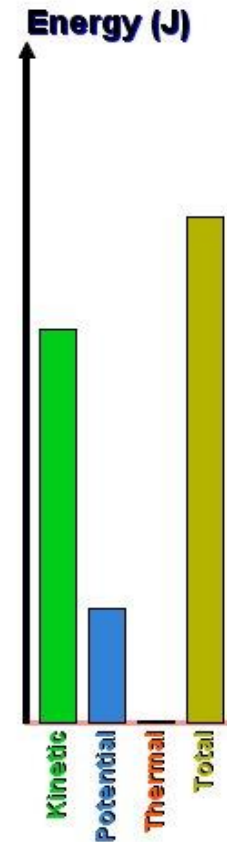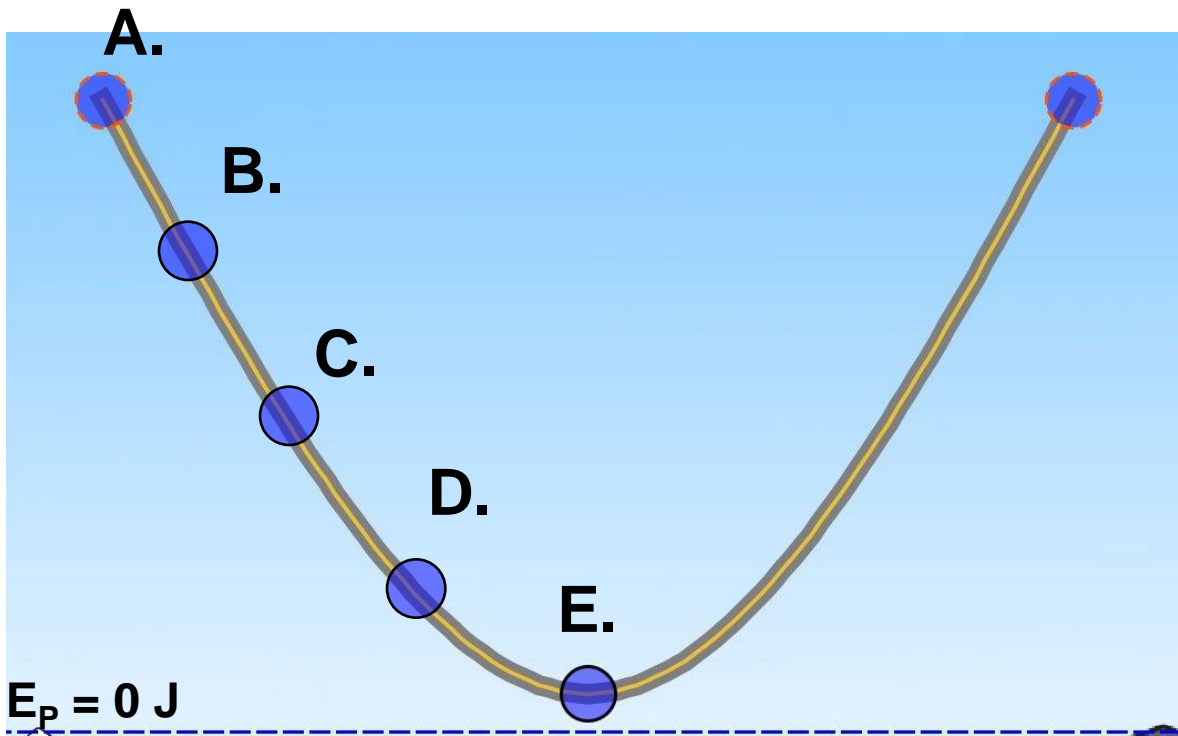
Solution

Answer: D

Justification: From the bar graph, the skater's potential energy is only one quarter of his total energy. Kinetic energy accounts for the other three quarters.
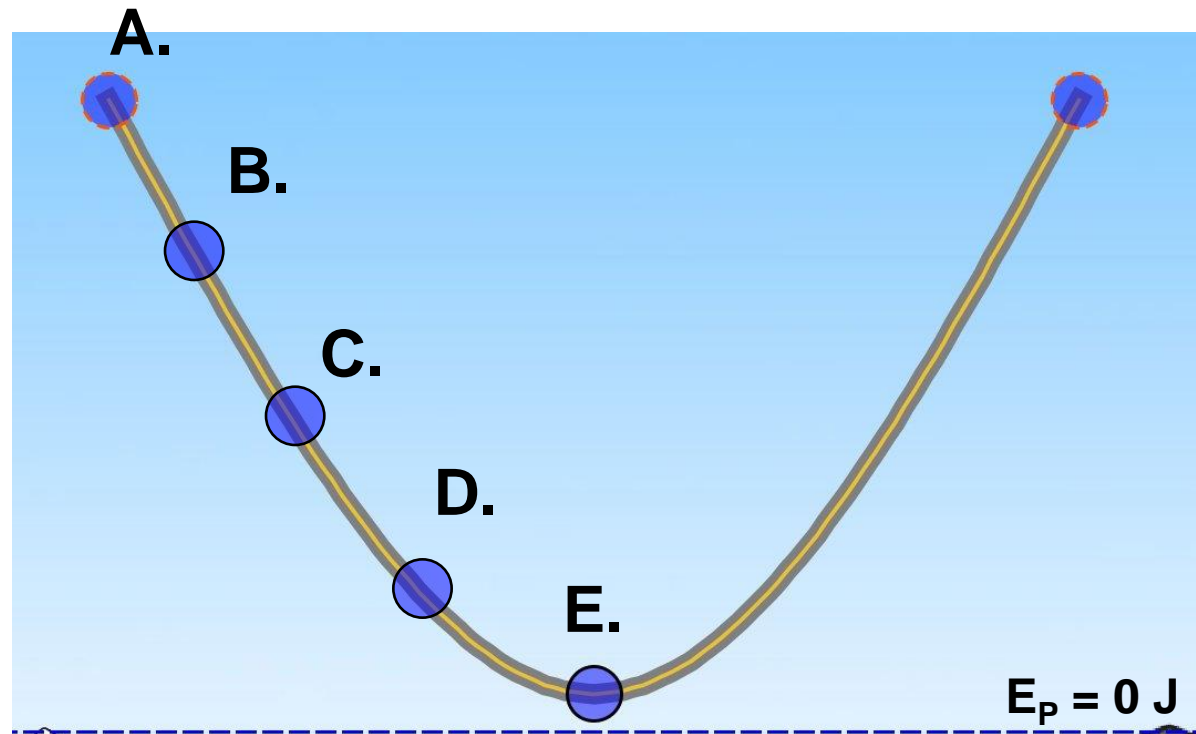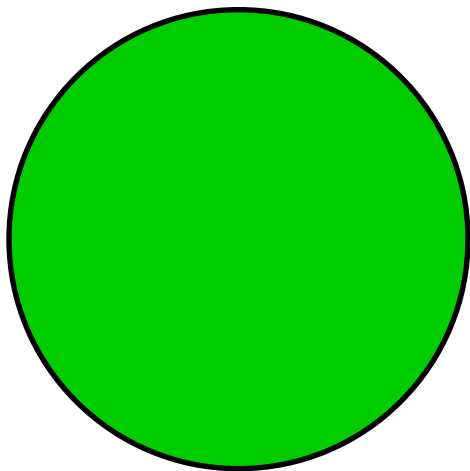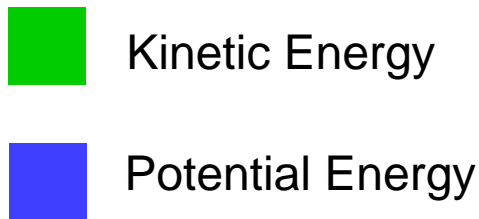
At the top of the slope (A) all of the skater's energy is potential. At B, the skater has gained some kinetic energy, but the energy is still mostly potential. At C, the skater has equal parts kinetic and potential energy. At D, three quarters of the way down the slope, or one quarter from the bottom, the skater has mostly kinetic energy, and some potential energy. At E, the skater has no height, and thus no potential energy.

Potential energy is directly proportional to height of the skater, so when the skater is one quarter of the distance from the bottom, as at D, his energy profile would match the bar graph.

Note: The skater can also be located on the right side of the curve.

Skateboard Physics X

The skater starts at point A from rest. The pie graph shows the energy of the skater at a later time. At which point on the track could the skater be located?

Kinetic Energy

Potential Energy

A.

B.

C.

D.

E.

$E_P = 0$ J

Solution

Answer: E

Justification: There is no potential energy and maximum kinetic energy.

As previously discussed, the skater has the most potential energy at the top of the slope. As the skater moves down the slope, his potential energy decreases as the kinetic energy increases.

The lowest point of the slope is located on the $E_p = 0$ J reference point. Energy cannot be created or destroyed in a system, so all of the energy must be in the form of kinetic energy.

Remember that height must be measured from a reference point when working with potential energy.

Skateboard Physics XI

The skater starts at point A from rest. The pie graph shows the energy of the skater at a later time. At which point on the track could the skater be located?

Kinetic Energy

Potential Energy

A.

B.

C.

D.

E.

$E_P = 0$ J
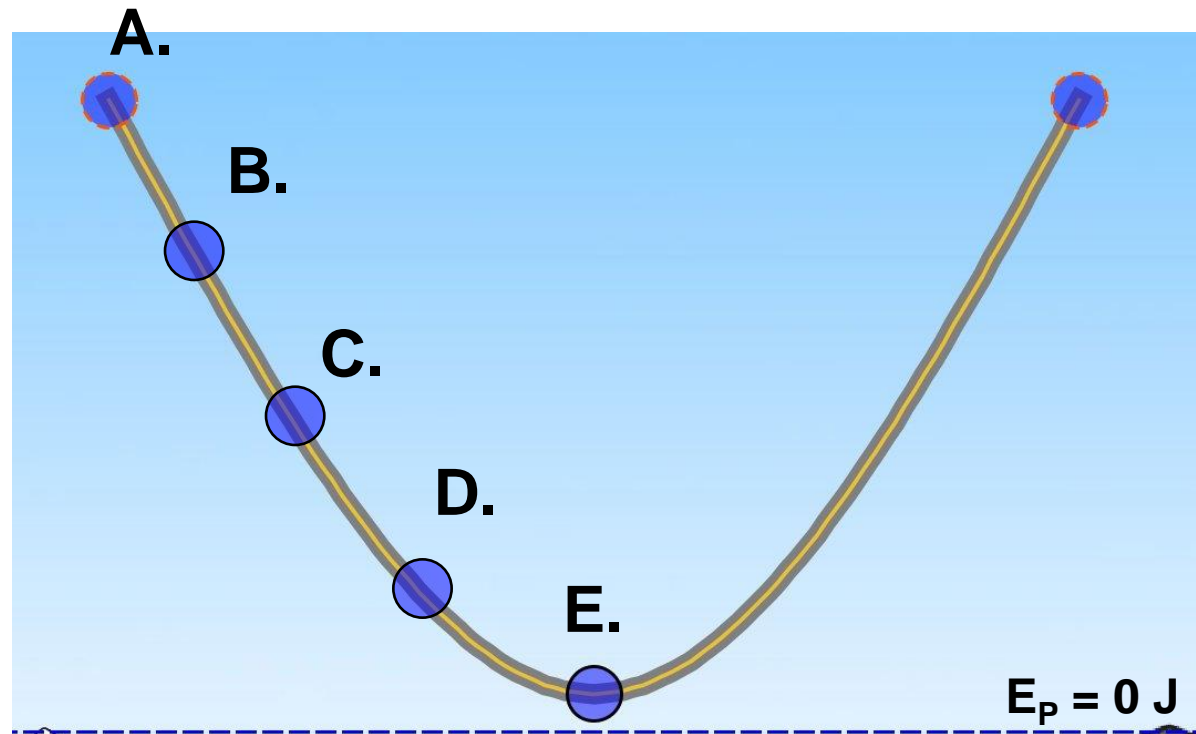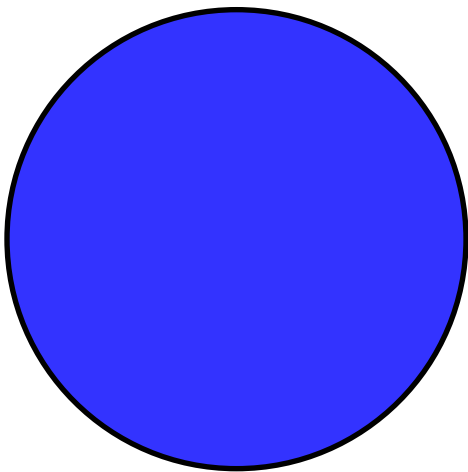
Solution

Answer: A

Justification: In the situation depicted in the diagram, the person has no kinetic energy (he is at rest). The amount of potential energy an object has is determined by its height from the reference point. At E, the object is at the lowest point and has no potential energy (if this point is chosen as the reference point for potential energy). Moving up the slope, potential energy increases and kinetic energy decreases. The skater has maximum potential energy at the highest point on the slope, at point A.