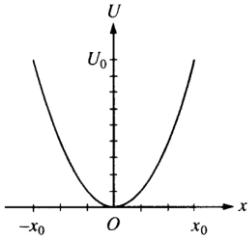
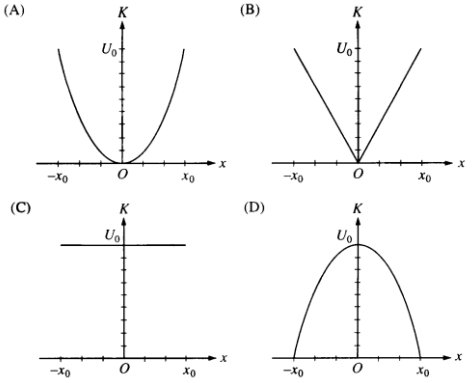
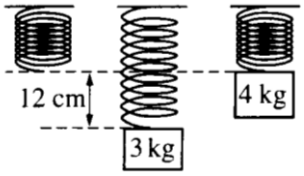
21. The graph shown represents the potential energy U as a function of displacement x for an object on the end of a spring moving back and forth with amplitude x_0. Which of the following graphs represents the kinetic energy K of the object as a function of displacement x?





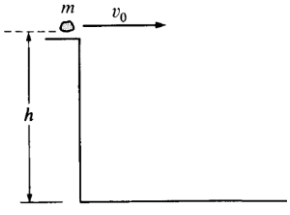
22. A child pushes horizontally on a box of mass m which moves with constant speed v across a horizontal floor. The coefficient of friction between the box and the floor is μ. At what rate does the child do work on the box?
(A) μmgv (B) mgv (C) $\mu mg/v$ (D) $\mu mg/v$

23. A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown. The 3.0 kg block is then replaced by a 4.0 kg block, and the new block is released from the position shown, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?
(A) 18 cm (B) 24 cm
(C) 32 cm (D) 48 cm

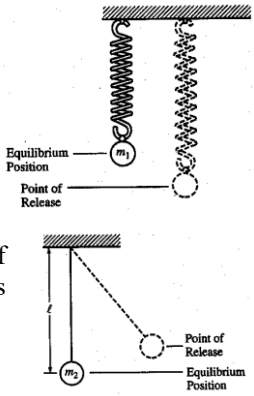


24. What is the kinetic energy of a satellite of mass m that orbits the Earth, of mass M, in a circular orbit of radius R?
(A) $\frac{1}{2}\frac{GMm}{R}$ (B) $\frac{1}{4}\frac{GMm}{R}$ (C) $\frac{1}{2}\frac{GMm}{R^2}$ (D) $\frac{GMm}{R^2}$

25. A rock of mass m is thrown horizontally off a building from a height h, as shown above. The speed of the rock as it leaves the thrower's hand at the edge of the building is v_0. What is the kinetic energy of the rock just before it hits the ground?
(A) mgh (B) $\frac{1}{2} mv_0^2$ (C) $\frac{1}{2} mv_0^2 - mgh$ (D) $\frac{1}{2} mv_0^2 + mgh$



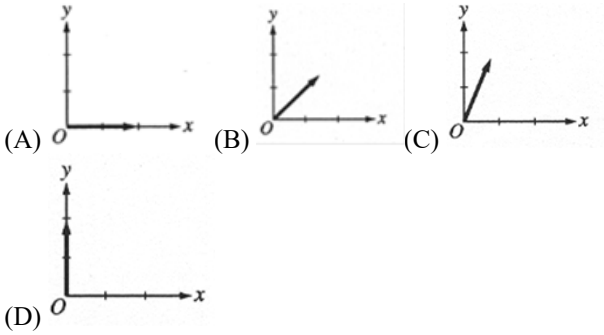
26. As shown in the image to the right, a sphere of mass m_1, which is attached to a spring, is displaced downward from its equilibrium position as shown above left and released from rest. A sphere of mass m_2, which is suspended from a string of length L, is displaced to the right as shown above right and released from rest so that it swings as a simple pendulum with small amplitude. Assume that both spheres undergo simple harmonic motion Which of the following is true for both spheres?



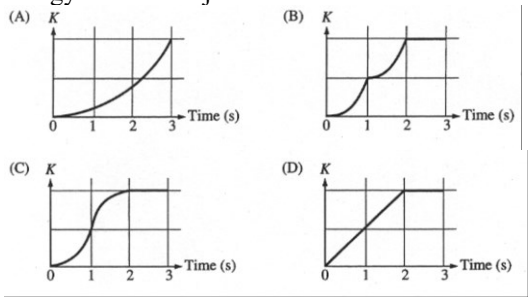
a. The maximum kinetic energy is attained as the sphere passes through its equilibrium position.
b. The minimum gravitational potential energy is attained as the sphere passes through its equilibrium position.
c. The maximum gravitational potential energy is attained when the sphere reaches its point of release.
d. The maximum total energy is attained only as the sphere passes through its equilibrium position.

Questions 27-28: *An object of mass m is initially at rest and free to move without friction in any direction in the xy-plane. A constant net force of magnitude F directed in the +x direction acts on the object for 1 s. Immediately thereafter a constant net force of the same magnitude F directed in the +y direction acts on the object for 1 s. After this, no forces act on the object.*

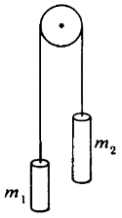
27. Which of the following vectors could represent the velocity of the object at the end of 3 s, assuming the scales on the x and y axes are equal?



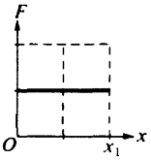
28. Which of the following graphs best represents the kinetic energy K of the object as a function of time?

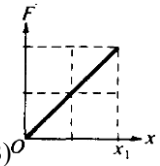


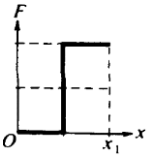
29. A system consists of two objects having masses m_1 and m_2 ($m_1 < m_2$). The objects are connected by a massless string, hung over a pulley as shown, and then released. When the object of mass m_2 has descended a distance h, the potential energy of the system has decreased by
(A) $(m_2 - m_1)gh$ (B) m_2gh (C) $(m_1 + m_2)gh$ (D) $\frac{1}{2}(m_1 + m_2)gh$

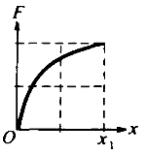


30. The following graphs, all drawn to the same scale, represent the net force F as a function of displacement x for an object that moves along a straight line. Which graph represents the force that will cause the greatest change in the kinetic energy of the object from x = 0 to x = x_1?

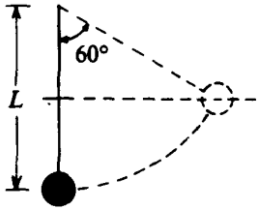
(A) 

(B) 

(C) 

(D) 

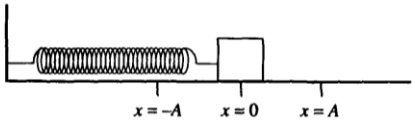
31. A pendulum consists of a ball of mass m suspended at the end of a massless cord of length L as shown. The pendulum is drawn aside through an angle of 60° with the vertical and released. At the low point of its swing, the speed of the pendulum ball is



(A) $\sqrt{gL}$ (B) $\sqrt{2gL}$ (C) ½gL (D) gL

32. A rock is lifted for a certain time by a force F that is greater in magnitude than the rock's weight W. The change in kinetic energy of the rock during this time is equal to the
a. work done by the net force (F - W)
b. work done by F alone
c. work done by W alone
d. difference in the potential energy of the rock before and after this time.

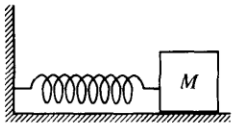
33. A block on a horizontal frictionless plane is attached to a spring, as shown. The block oscillates along the x-axis with amplitude A. Which of the following statements about energy is correct?



a. The U of the spring is at a minimum at x = 0.
b. The U of the spring is at a minimum at x = A.
c. The U of the block is at a minimum at x = 0.
d. The U of the block is at a maximum at x = A.

34. A spring-loaded gun can fire a projectile to a height **h** if it is fired straight up. If the same gun is pointed at an angle of 45° from the vertical, what maximum height can now be reached by the projectile?
(A) h/4 (B) $\frac{h}{2\sqrt{2}}$ (C) h/2 (D) $\frac{h}{\sqrt{2}}$

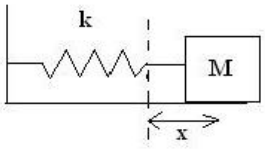
35. An ideal massless spring is fixed to the wall at one end, as shown. A block of mass M attached to the other end of the spring oscillates with amplitude A on a frictionless, horizontal surface. The maximum speed of the block is v_m. The force constant of the spring is



(A) $\frac{Mgv_m}{2A}$ (B) $\frac{Mv_m^2}{2A}$ (C) $\frac{Mv_m^2}{A^2}$ (D) $\frac{Mv_m^2}{2A^2}$

36. A person pushes a block of mass M = 6.0 kg with a constant speed of 5.0 m/s straight up a flat surface inclined 30.0° above the horizontal. The coefficient of kinetic friction between the block and the surface is μ = 0.40. What is the net force acting on the block?
(A) 0 N (B) 21 N (C) 30 N (D) 51 N

37. A block of mass *M* on a horizontal surface is connected to the end of a massless spring of spring constant *k*. The block is pulled a distance *x* from equilibrium and when released from rest, the block moves toward equilibrium. What coefficient of kinetic friction between the surface and the block would allow the block to return to equilibrium and stop?



(A) $\frac{kx^2}{2Mg}$ (B) $\frac{kx}{Mg}$ (C) $\frac{kx}{2Mg}$ (D) $\frac{Mg}{2kx}$

38. An object is dropped from rest from a certain height. Air resistance is negligible. After falling a distance d, the object's kinetic energy is proportional to which of the following?
(A) $1 / d^2$ (B) $1 / d$ (C) $\sqrt{d}$ (D) d

39. An object is projected vertically upward from ground level. It rises to a maximum height H. If air resistance is negligible, which of the following must be true for the object when it is at a height H/2?
a. Its speed is half of its initial speed.
b. Its kinetic energy is half of its initial kinetic energy.
c. Its potential energy is half of its initial potential energy.
d. Its total mechanical energy is half of its initial value.