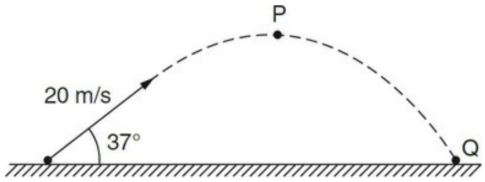
Student #: _____ Student Name: _____

AP PHYSICS C CLASS 3: WORK AND ENERGY

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and place the letter of your choice in the corresponding box on the student answer sheet.

Questions 1–2: A 2 kg projectile is launched with a speed of 20 m/s from horizontal ground at an angle of 37° to the horizontal as shown. Point P is at the top of the path, and point Q is at the end of the path, just before the projectile again reaches the ground.



1. The kinetic energy of the projectile at point P is
   (A) 108 J
   (B) 225 J
   (C) 256 J
   (D) 400 J
   (E) 525 J

2. The kinetic energy of the projectile at point Q is
   (A) 108 J
   (B) 225 J
   (C) 256 J
   (D) 400 J
   (E) 525 J

3. If a projectile thrown directly upward reaches a maximum height h and spends a total time in the air of T, then returning to the original location, the average power of the gravitational force during the trajectory is
   (A) $P = 2mgh/T$
   (B) $P = -2mgh/T$
   (C) 0
   (D) $P = mgh/T$
   (E) $P = -mgh/T$

4. Given that the constant net force on an object and the object's displacement, which of the following quantities can be calculated?
   (A) the net change in the object's velocity
   (B) the net change in the object's mechanical energy
   (C) the average acceleration
   (D) the net change in the object's kinetic energy
   (E) the net change in the object's potential energy

5. The force acting on an object varies with the equation $F(x) = -3x^2 - 2x - 4$, where force is in newtons and displacement is in meters. The potential energy at $x = 2$ m is
   (A) zero
   (B) 20 J
   (C) 40 J
   (D) −20 J
   (E) −40 J

6. If the only force acting on an object is given by the equation $F(x) = 2 - 4x$ (where the force is measured in newtons and position in meters), what is the change in the object's kinetic energy as it moves from $x = 2$ to $x = 1$?
   (A) +4 J
   (B) −4 J
   (C) +2 J
   (D) −2 J
   (E) +8 J

7. The potential energy of an object varies with the equation $U(x) = 2x^2 + x - 6$, where force is in newtons and displacement is in meters. A force F vs. displacement x graph would yield which of the following?
   (A) A straight, horizontal line
   (B) A parabola
   (C) An exponential decay curve
   (D) A straight line with a positive slope
   (E) A straight line with a negative slope

8. A particle of mass m moves according to the displacement equation $x = 2t^{5/2}$. The kinetic energy of the particle as a function of time is
   (A) $10mt^{5/2}$
   (B) $10mt^{3/2}$
   (C) $\frac{25}{2}mt^3$
   (D) $5mt^2$
   (E) $2mt^{3/2}$

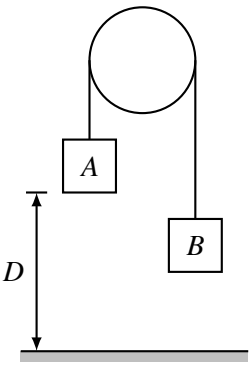
9. An electron travels in a circle around a hydrogen nucleus at a very high speed. The work done by the electrostatic force acting on the electron after one complete revolution is

(A) zero
(B) positive
(C) negative
(D) equal to the kinetic energy of the electron
(E) equal to the potential energy of the electron

10. An object is moved from rest at point P to rest at point Q in a gravitational field. The net work against the gravitational field depends on the

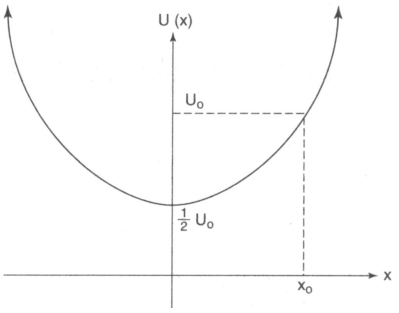
(A) mass of the object and the positions of P and Q
(B) mass of the object only
(C) positions of P and Q only
(D) length moved between points P and Q
(E) coefficient of friction

11. Two blocks of mass m_A and m_B are connected by a string that passes over a light pulley. The mass of A is larger than the mass of B. The speed of mass A just before reaching the floor is:



(A) $\sqrt{\frac{2(m_A - m_B)}{m_A + m_B} gD}$
(B) $\sqrt{\frac{2(m_A + m_B)}{m_A - m_B} gD}$
(C) $\sqrt{\frac{2m_A}{m_A + m_B} gD}$
(D) $\sqrt{\frac{2m_B}{m_A + m_B} gD}$
(E) $\sqrt{\frac{2m_A}{m_B} gD}$

Questions 12–13: Consider the potential energy function shown below.



12. Assuming that no non-conservative forces are present, if a particle of mass m is released from position x_0, what is the maximum speed it will achieve?

(A) $\sqrt{4U_0/m}$
(B) $\sqrt{2U_0/m}$
(C) $\sqrt{U_0/m}$
(D) $\sqrt{U_0/2m}$
(E) The particle will achieve no maximum speed but instead will continue to accelerate indefinitely.

13. Which of the following is the most accurate description of the system introduced in the previous question?

(A) A stable equilibrium
(B) An unstable equilibrium
(C) A neutral equilibrium
(D) A bound system
(E) There is a linear restoring force

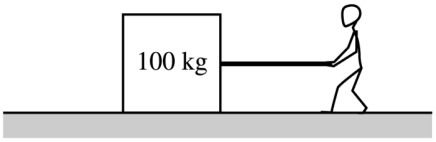
14. A machine can lift large weights according to the power equation $P(t) = 4t^3 + 3t^2 - 2$, where power is in watts and time is in seconds. The energy expended by the machine from $t = 0$ to $t = 10$ s is

(A) 1260 J
(B) 3630 J
(C) 9240 J
(D) 10 980 J
(E) 18 150 J

AP PHYSICS C CLASS 3: WORK AND ENERGY
SECTION II
3 Questions

Directions: Answer all questions. The parts within a question may not have equal weight. All final numerical answers should include appropriate units. Credit depends on the quality of your solutions and explanations, so you should show your work. Credit also depends on demonstrating that you know which physical principles would be appropriate to apply in a particular situation. Therefore, you should clearly indicate which part of a question your work is for.

15. The 100 kg box shown below is being pulled along the x-axis by a student. The box slides across a rough surface, and its position x varies with time t according to the equation $x = 0.5t^3 + 2t$, where x is in meters and t is in seconds.



(a) Determine the speed of the box at time $t = 0$.

(b) Determine the following as functions of time t.

i. The kinetic energy of the box

ii. The net force acting on the box

iii. The power being delivered to the box

(c) Calculate the net work done on the box in the interval $t = 0$ to $t = 2$ s.

16. A 3 kg object is moving along the x-axis in a region where its potential energy as a function of x is given as $U(x) = 4.0x^2$, where U is in joules and x is in meters. When the object passes the point $x = -0.50$ m, its velocity is +2 m/s. All forces acting on the object are conservative.

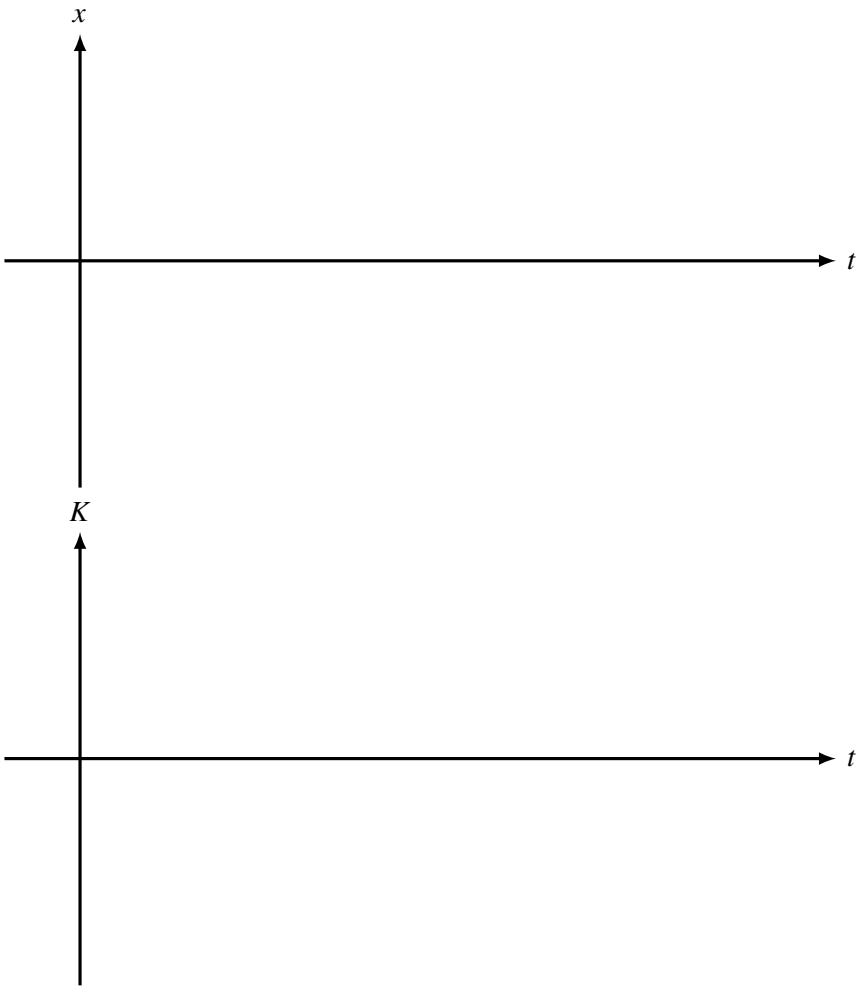
(a) Calculate the total mechanical energy of the object.

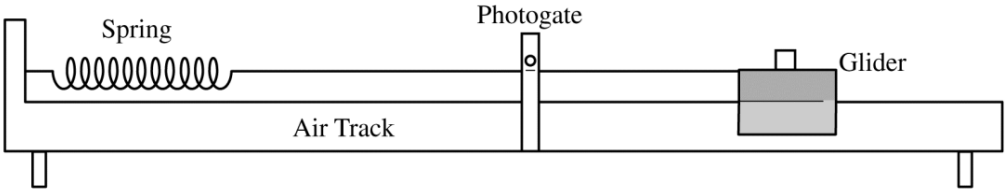
(b) Calculate the x-coordinate of any points at which the object has zero kinetic energy.

(c) Calculate the magnitude of the momentum of the object at $x = 0.60$ m.

(d) Calculate the magnitude of the acceleration of the object as it passes $x = 0.60$ m.

(e) On the axes below, sketch graphs of the object's position x versus time t and kinetic energy K versus time t. Assume that $x = 0$ at time $t = 0$. The two graphs should cover the same time interval and use the same scale on the horizontal axes.



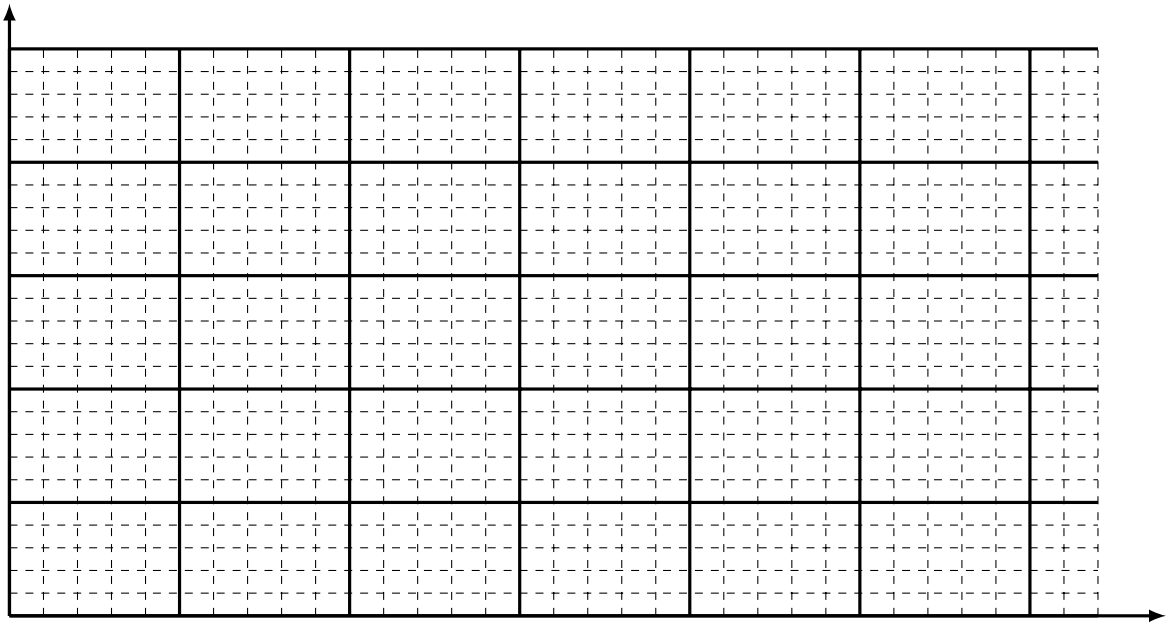


17. The apparatus above is used to study conservation of mechanical energy. A spring of force constant 40 N/m is held horizontal over a horizontal air track, with one end attached to the air track. A light string is attached to the other end of the spring and connects it to a glider of mass m. The glider is pulled to stretch the spring an amount x from equilibrium and then released. Before reaching the photogate, the glider attains its maximum speed and the string becomes slack. The photogate measures the time t that it takes the small block on top of the glider to pass through. Information about the distance x and the speed v of the glider as it passes through the photogate are given below.

Trial #	Extension of the Spring x (m) x (m)	Speed of Glider v (m/s)	Extension Squared x^2 (m^2)	Speed Squared v^2 (m^2/s^2)
1	0.30×10^{-1}	0.47	0.09×10^{-2}	0.22
2	0.60×10^{-1}	0.87	0.36×10^{-2}	0.76
3	0.90×10^{-1}	1.3	0.81×10^{-2}	1.7
4	1.2×10^{-1}	1.6	1.4×10^{-2}	2.6
5	1.5×10^{-1}	2.2	2.3×10^{-2}	4.8

(a) Assuming no energy is lost, write the equation for conservation of mechanical energy that would apply to this situation.

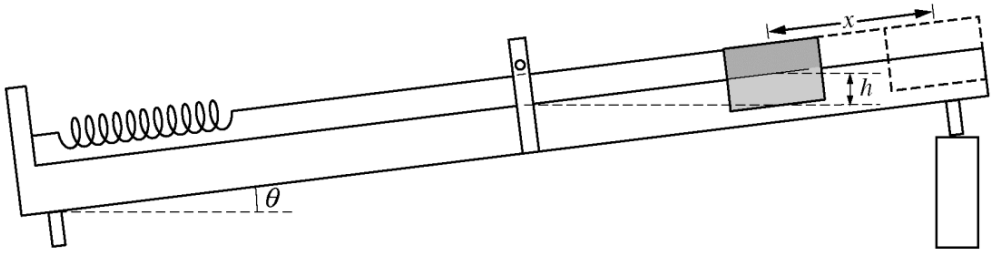
(b) On the grid below, plot v^2 versus x^2. Label the axes, including units and scale.



(c) i. Draw a best-fit straight line through the data.

ii. Use the best-fit line to obtain the mass m of the glider.

(d) The track is now tilted at an angle θ as shown below. When the spring is unstretched, the center of the glider is a height h above the photogate. The experiment is repeated with a variety of values of x.



i. Assuming no energy is lost, write the new equation for conservation of mechanical energy that would apply to this situation.

ii. Will the graph of v^2 versus x^2 for this new experiment be a straight line? Justify your answer.

_____ Yes _____ No