Student #: _____ Student Name: _____

AP Physics Class 7: Simple Harmonic Motion

_____ 1. A simple pendulum has a mass m, length L, and period T. If the pendulum mass is replaced by a mass of $2m$, the period will be

(a) doubled
(b) halved
(c) quartered
(d) quadrupled
(e) unchanged

_____ 2. A mass oscillates on the end of a spring that obeys Hooke's law. Which of the following statements is true?

(a) The amplitude of oscillation is equal to the potential energy of the spring.
(b) The kinetic energy of the oscillating mass is constant.
(c) Maximum potential energy occurs when the mass reaches the equilibrium position.
(d) The potential energy of the spring at the amplitude is equal to the kinetic energy at the equilibrium position.
(e) The kinetic energy of the spring at the amplitude is equal to the potential energy at the equilibrium position.

_____ 3. A superball is dropped from a height of $5.0\,\text{meters}$ above a floor. The ball bounces off the floor in a perfectly elastic collision so that it rises to the same height with each bounce. The motion of the ball can be described as

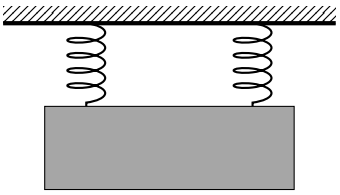
(a) harmonic motion with a period of 2 s
(b) harmonic motion with a period of 1 s
(c) harmonic motion with a period of $1/2$ s
(d) motion with a constant velocity
(e) motion with a constant momentum

_____ 4. An object oscillates in simple harmonic motion along the x-axis according to the equation $x = 6\cos(4t)$. The period of oscillation of the object is

(a) $1/4$ s
(b) 4 s
(c) $\pi/4$ s
(d) $\pi/2$ s
(e) 4π s

_____ 5. A mass m oscillates on the end of a string of length L. The frequency of the pendulum is f. How would you increase the frequency of the pendulum to $2f$?

(a) Increase the length of the pendulum to $4L$
(b) Decrease the length of the pendulum to $1/4L$
(c) Increase the length of the pendulum to $2L$
(d) Decrease the length of the pendulum to $1/2L$
(e) Decrease the mass of the pendulum to $1/2m$



_____ 6. A mass hangs from two parallel springs, each with the same spring constant k. Compared to the period T of the same mass oscillating on one of the springs, the period of oscillation of the mass with both springs connected to it is

(a) $1/4T$
(b) $1/2T$
(c) T (unchanged)
(d) $2T$
(e) $4T$

_____ 7. Which of the following is generally true for an object in simple harmonic motion on a spring of constant k?

(a) The greater the spring constant k, the greater the amplitude of the motion.
(b) The greater the spring constant k, the greater the period of the motion.
(c) The greater the spring constant k, the greater the frequency of the motion.
(d) The lower the spring constant k, the greater the frequency of the motion.
(e) The lower the spring constant k, the greater the kinetic energy of the motion.

Questions 8-10: A harmonic oscillator follows the equation $\frac{d^2x}{dt^2} = -4x$. The spring constant k is $4\,\mathrm{N/m}$.

_____ 8. The angular frequency of the harmonic motion is

(a) zero
(b) $2\,\mathrm{rad/s}$
(c) $4\,\mathrm{rad/s}$
(d) $8\,\mathrm{rad/s}$
(e) $16\,\mathrm{rad/s}$

_____ 9. The mass m oscillating on the spring is

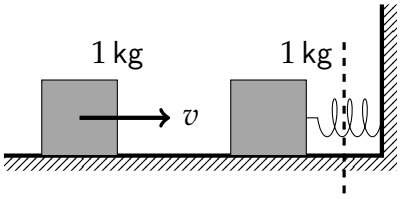
(a) $1\,\mathrm{kg}$
(b) $2\,\mathrm{kg}$
(c) $4\,\mathrm{kg}$
(d) $8\,\mathrm{kg}$
(e) $16\,\mathrm{kg}$

_____ 10. The period T of oscillation is

(a) zero
(b) $\pi/4\mathrm{s}$
(c) $\pi/2\mathrm{s}$
(d) $\pi\,\mathrm{s}$
(e) $2\pi\,\mathrm{s}$

_____ 11. A pendulum of length L has a period of $2\,\mathrm{s}$ on Earth. A planetary explorer takes the same pendulum of length L to another planet where its period is $1\,\mathrm{s}$. The gravitational acceleration on the surface of this planet is most nearly

(a) $8g$
(b) $4g$
(c) $2g$
(d) $12g$
(e) $14g$



_____ 12. A block of mass $1.0\,\mathrm{kg}$ is sliding on a frictionless horizontal surface with a speed of $4.0\,\mathrm{m/s}$ when it collides inelastically with another $1.0\,\mathrm{kg}$ block attached to a spring. The spring compresses a distance of $0.5\,\mathrm{m}$ after the collision. The force constant k of the spring is

(a) $2\,\mathrm{N/m}$
(b) $4\,\mathrm{N/m}$
(c) $8\,\mathrm{N/m}$
(d) $16\,\mathrm{N/m}$
(e) $32\,\mathrm{N/m}$

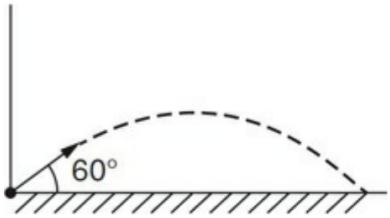
_____ 13. A block of mass $0.5\,\mathrm{kg}$ rests up against a compressed spring of force constant $5\,\mathrm{N/m}$. The spring is released, and the block travels a distance of $1.0\,\mathrm{m}$ when the block leaves the spring at the edge of the horizontal frictionless table, and is projected to the floor. The table is $1.5\,\mathrm{m}$ high. The horizontal distance from the table the block lands on the floor is

(a) $1.2\,\mathrm{m}$
(b) $1.7\,\mathrm{m}$
(c) $2.1\,\mathrm{m}$
(d) $2.8\,\mathrm{m}$
(e) $3.4\,\mathrm{m}$

The following questions are "review" questions for kinematics.

_____ 14. A golf ball is hit from level ground and has a horizontal range of $100\,\text{m}$. The ball leaves the golf club at an angle of 60° to the level ground. At what other angle(s) can the ball be struck at the same initial velocity and still have a range of $100\,\text{m}$?

(a) 30°
(b) 20° and 80°
(c) 10° and 120°
(d) 45° and 135°
(e) There is no other angle other than 60° in which the ball will have a range of $100\,\text{m}$.

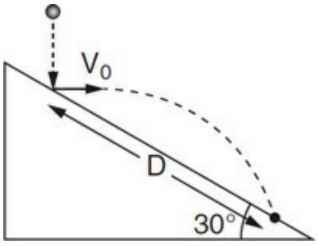


_____ 15. A particle moves on a horizontal surface with a constant acceleration of $6\,\text{m/s}^2$ in the x-direction and $4\,\text{m/s}^2$ in the y-direction. The initial velocity of the particle is $3\,\text{m/s}$ in the x-direction. The speed of the particle after $4\,\text{s}$ is

(a) $16\,\text{m/s}$
(b) $27\,\text{m/s}$
(c) $31\,\text{m/s}$
(d) $44\,\text{m/s}$
(e) $985\,\text{m/s}$

_____ 16. The displacement of the particle (from the previous question) from its initial position is

(a) $16\,\text{m}$
(b) $32\,\text{m}$
(c) $60\,\text{m}$
(d) $68\,\text{m}$
(e) $92\,\text{m}$

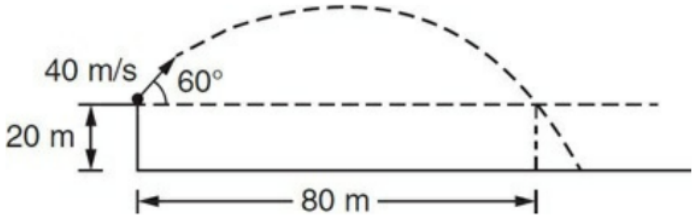


_____ 17. A rubber ball is dropped from rest onto a plane angled at 30° to the horizontal floor and bounces off the plane with a horizontal speed v_o. The ball lands on the plane a distance D along the plane, as shown above. In terms of v_o, D, and g, the speed of the ball just before striking the plane is

(a) v_o
(b) $\left(v_o^2 + 2D\sin\theta g\right)^{\frac{1}{2}}$
(c) $\left(v_o + \dfrac{D\sin\theta}{g}\right)^{\frac{1}{2}}$

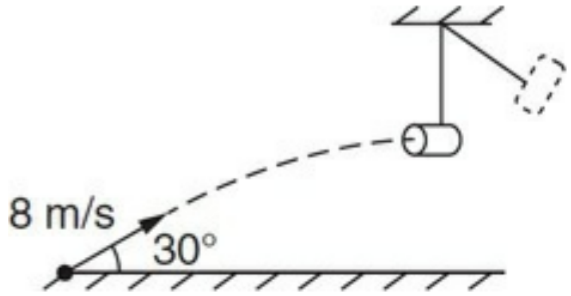
(d) $\left(v_o^2 + \dfrac{D\sin\theta}{g}\right)^{\frac{1}{2}}$

(e) $(2D\sin\theta g)^{\frac{1}{2}}$



_____ 18. A projectile is launched from a platform $20\,\text{m}$ high above level ground. The projectile is launched with a velocity of $40\,\text{m/s}$ at an angle of $60°$ above the horizontal. The projectile follows a parabolic path and reaches its original height at a horizontal distance of $80\,\text{m}$, but moves past the height of the cliff to strike the ground below. The total time from the launch until it strikes the ground is

(a) $2\,\text{s}$
(b) $4\,\text{s}$
(c) $6\,\text{s}$
(d) $9\,\text{s}$
(e) $10\,\text{s}$



_____ 19. A small ball is launched with a speed of $8\,\text{m/s}$ at an angle of $30°$ from the horizontal. A cup is hung so that it is in position to catch the ball when it reaches its maximum height. How far above the floor should the cup be hung to catch the ball?

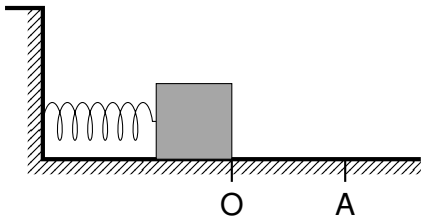
(a) $2.4\,\text{m}$
(b) $1.6\,\text{m}$
(c) $1.0\,\text{m}$
(d) $0.8\,\text{m}$
(e) $0.4\,\text{m}$

_____ 20. A small airplane can fly at $200\,\text{km/h}$ with no wind. The pilot of the plane would like to fly to a destination $100\,\text{km}$ due north of his present position, but there is a crosswind of $50\,\text{km/h}$ east. How much time is required for the plane to fly north to its destination?

(a) less than $1/2\,\text{h}$
(b) $1/2\,\text{h}$
(c) more than $1/2\,\text{h}$
(d) $1\,\text{h}$
(e) more than $1\,\text{h}$

Free-Response Questions:

1. A mass m oscillates on an ideal spring of spring constant k on a frictionless horizontal surface. The mass is pulled aside to a distance A from its equilibrium position, and released.



   (a) In terms of the given quantities, at what distance from the equilibrium position is the potential energy of the mass equal to its kinetic energy?
   (b) In terms of the given quantities, what is the acceleration of the mass when it is at the amplitude A?

2. A mass oscillates in simple harmonic motion as shown by the position x vs. time t graph below.

(a) What is the frequency of oscillation?
(b) Write the equation that represents the speed of the mass as a function of time.

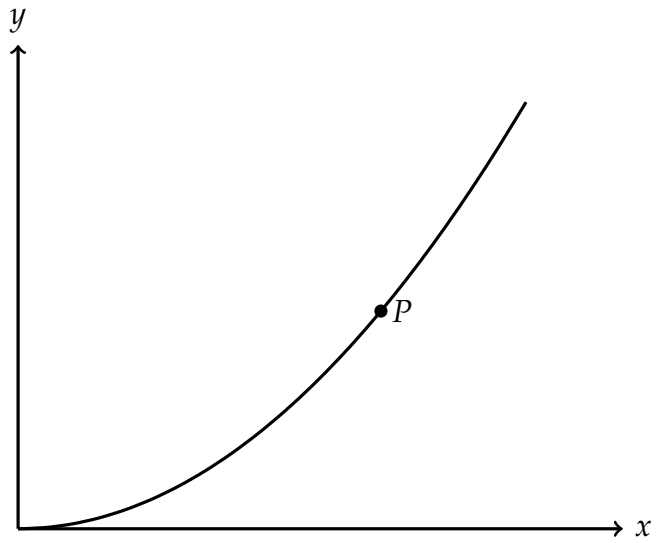
3. The acceleration vs. time graph shows the motion of an elevator during a 20-second time interval. The elevator starts from rest at time $t = 0$.

   (a) Determine the instantaneous velocity of the elevator at the end of $10\,\text{s}$.

   (b) Determine the displacement of the elevator after $5\,\text{s}$.

   (c) On the axes below, sketch the graph that represents the velocity vs. time graph for the elevator for the 20-second time interval.

4. A particle follows a parabolic path with the equation $y = 2x^2$ as shown. The x-component of the particle's velocity v_x as a function of time t is 6, that is, the horizontal displacement is $x = 6t$.



(a) Determine the y-component of the particle's velocity v_y as a function of time.

(b) On the diagram above, sketch arrows to represent the horizontal and vertical components of the particle's acceleration at point P.