PHYSICS 1
Section I
Time–45 minutes
30 Questions

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.

Note: To simplify calculations, you may use $g = 10\,\text{m/s}^2$ in all problems.

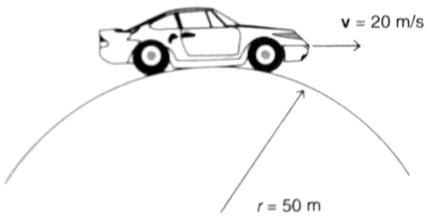
Questions 1–2 A 10 kg projectile is launched at a 60° angle to the ground with a velocity of 200 m/s. Neglect air resistance.

1. Compare this projectile with a 5 kg projectile launched under the same conditions but at a 30° angle. The 5-kg projectile will

   (A) go higher up and farther along the ground
   (B) go equally high and equally far along the ground
   (C) neither go as high nor as far along the ground
   (D) not go as high but go equally far along the ground

2. As the launch angle is lowered to 45°, the maximum horizontal distance traveled by the projectile will

   (A) decrease
   (B) increase
   (C) remain the same
   (D) be impossible to determine without more information



3. A car with a 500 N driver goes over a hill that has a radius of 50 meters as shown in the figure above. The velocity of the car is 20 m/s. What are the approximate force and direction that the car exerts on the driver?

   (A) 900 N, up
   (B) 400 N, down
   (C) 100 N, up
   (D) 500 N, up

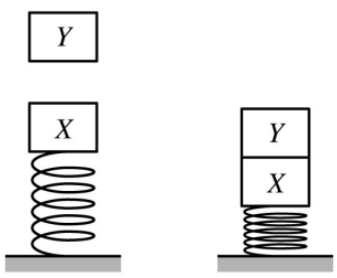
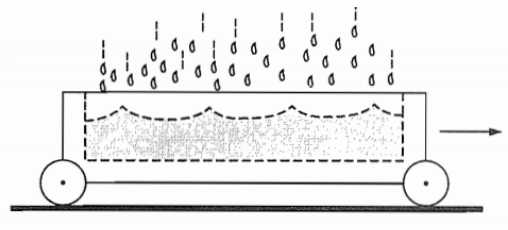


Figure 1 Figure 2

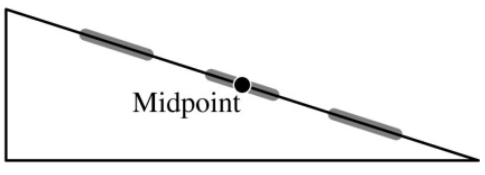
4. Block Y with mass m_Y falls onto and sticks to block X, which is attached to a vertical spring, as shown in Figure 1. A short time later, as shown in Figure 2, the blocks are momentarily at rest. At that moment, block Y exerts a force of magnitude F down on block X, and block X exerts a force of magnitude F up on block Y. Which of the following correctly relates F_{up}, F_{down}, and $m_Y g$ at the instant shown in Figure 2?

   (A) $\left(F_{\text{up}} = F_{\text{down}}\right) > m_Y g$
   (B) $\left(F_{\text{up}} = m_Y\right) > F_{\text{down}}$
   (C) $m_Y g > F_{\text{up}} > F_{\text{down}}$
   (D) $F_{\text{up}} = F_{\text{down}} = m_Y g$



5. An open cart on a level surface is rolling without frictional loss through a vertical downpour of rain, as shown above. As the cart rolls, an appreciable amount of rainwater accumulates in the cart. The speed of the cart will

   (A) increase because of conservation of momentum
   (B) increase because of conservation of energy
   (C) decrease because of conservation of momentum
   (D) decrease because of conservation of energy

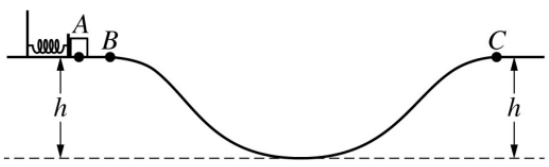


6. A block is released from rest and slides down a ramp. The surface of the ramp has three rough sections where the friction between the surface and the block is not negligible, as shown by the shaded regions above. Measuring which of the following will allow for the best estimate of the block's instantaneous acceleration when the block is at the midpoint of the ramp?

   (A) The total distance traveled by the block and the total elapsed time
   (B) The final speed of the block and the total elapsed time
   (C) The distance between points just before and just after the midpoint and the time it takes the block to travel between them
   (D) The speed of the block at points just before and just after the midpoint and the time it takes the block to travel between them

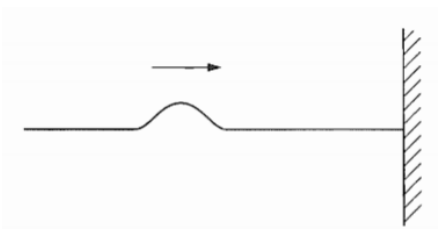
7. A solid metal ball and a hollow plastic ball of the same external radius are released from a large vacuum chamber. When each has fallen 1 m, they both have the same

   (A) inertial
   (B) speed
   (C) momentum
   (D) kinetic energy
   (E) change in potential energy



8. A block is held at rest against a compressed spring at point A at the top of a frictionless track of height h, as shown above. The block is released, loses contact with the spring at point B, and slides along the track until it passes point C, also at height h. How do the potential energy U of the block-Earth system and the kinetic energy K of the block at point C compare with those at point A?

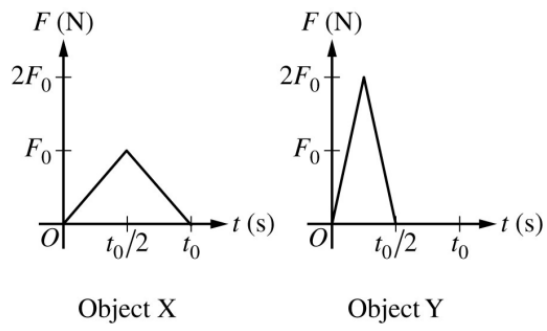
	Potential Energy of Block-Earth System	Kinetic Energy of Block
(A)	$U_C = U_A$	$K_C = K_A$
(B)	$U_C = U_A$	$K_C > K_A$
(C)	$U_C > U_A$	$K_C = K_A$
(D)	$U_C > U_A$	$K_C > K_A$



9. One end of a horizontal string is fixed to a wall. A transverse wave pulse is generated at the other end, moves toward the wall as shown above, and is reflected at the wall. Properties of the reflected pulse include which of the following?

I. It has greater speed than that of the incident pulse.
II. It has greater amplitude than that of the incident pulse.
III. It is on the opposite side of the string from the incident pulse.

(A) I only
(B) III only
(C) I and II only
(D) I and III only
(E) I, II and III



Object X Object Y

10. Objects X and Y are constrained to move along a straight line. The graphs above show the net force exerted along that line on each of the objects as functions of time. Which of the following correctly ranks the change in momentum Δp of the objects?

(A) $\Delta p_X < \Delta p_Y$
(B) $\Delta p_X = \Delta p_Y$
(C) $\Delta p_X > \Delta p_Y$
(D) The ranking cannot be determined without knowing the masses of the objects.

11. Three forces at on an object. If the object is in translational equilibrium, which of the following must be true?

I. The vector sum of the three forces must be equal
II. The magnitudes of the three forces must be equal
III. All three forces must be parallel

(A) I only
(B) II only
(C) I and III only
(D) II and III only
(E) I, II and III

Figure 1

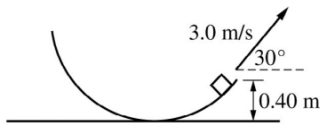


Figure 2

Questions 12–14 The figures above show a small block of mass 0.20 kg on a track in the shape of a circular arc. The block is released from rest at a height H above the floor, as shown in Figure 1. The block slides along the track with negligible friction and leaves it at a height of 0.40 m above the floor and a speed of 3.0 m/s at a 30° angle, as shown in Figure 2.

12. The height H is most nearly

(A) 0.45 m
(B) 0.51 m
(C) 0.86 m
(D) 1.7 m

13. The magnitude of the gravitational force exerted on the block is F_g, and the magnitude of the normal force exerted by the track on the block is F_n. Which of the following correctly compares the magnitudes of these two forces when the block is at the lowest point on the track?

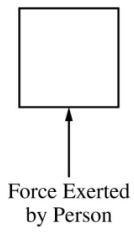
(A) $F_n > F_g$
(B) $F_n = F_g$
(C) $F_n < F_g$
(D) The magnitudes cannot be compared without knowing the radius of the arc of the track.

14. After the block leaves the track, what is the block's speed when it reaches the highest point of its motion?

(A) 0
(B) 1.5 m/s
(C) 2.6 m/s
(D) 3.0 m/s

15. Two satellites are in circular orbits around Earth. Satellite 1 has mass m_0 and an orbital radius of $2R_E$, where R_E is the radius of Earth. Satellite 2 has mass $2m_0$ and an orbital radius of $3R_E$. Which of the following correctly compares the magnitude F of the force exerted by Earth on each satellite and the speed v of each satellite?

	Force	Speed
(A)	$F_1 > F_2$	$v_1 > v_2$
(B)	$F_1 > F_2$	$v_2 > v_1$
(C)	$F_2 > F_1$	$v_1 > v_2$
(D)	$F_2 > F_1$	$v_2 > v_1$

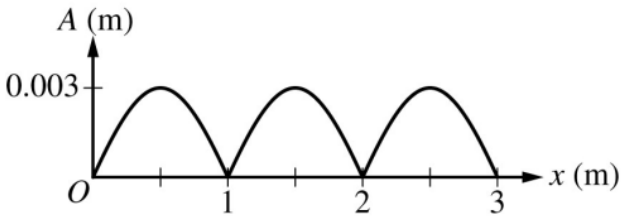


16. A person exerts an upward force on a box, as shown above. The box may be moving upward, downward, or not at all while the person exerts the upward force. For which of the following motions of the box is the work done by the person on the box correctly indicated?

	Motion of Box	Work Done by Person on Box
(A)	No motion	Positive
(B)	Upward, decreasing speed	Negative
(C)	Downward, constant speed	Zero
(D)	Downward, increasing speed	Negative

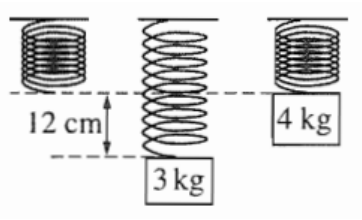
17. In the setup shown above, a student uses motion detector 1 to measure the speed v_i of a cart with mass m before it collides with and sticks to a stationary cart with mass M. Motion detector 2 measures the speed v_f of the carts after the collision. The student repeats the experiment several times using different values of v_i and creates a graph of v_f as a function of v_i. The slope of this graph is most nearly equal to

(A) $\frac{m}{M}$
(B) $\frac{m}{M+m}$
(C) $\frac{M-m}{M+m}$
(D) $\sqrt{\frac{m}{M+m}}$



18. A standing wave is produced on a horizontal string of length 3 m that is fixed at both ends. The graph above shows the amplitude A of the vertical oscillations of points on the string as a function of the distance x from one end of the string. For any point on the string, the amplitude is the absolute value of the maximum displacement of that point from its equilibrium position. The wavelength of the standing wave is

(A) 1.0 m
(B) 1.5 m
(C) 2.0 m
(D) 3.0 m



19. A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown above. The 3.0 block is then replaced by a 4.0 kg block, and the new block is released from the positive shown above, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?

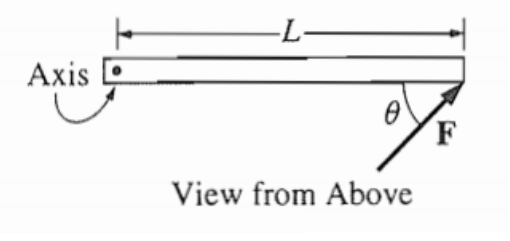
(A) 9 cm
(B) 18 cm
(C) 24 cm
(D) 32 cm
(E) 48 cm

20. Which of the following statements about a satellite in an elliptical orbit around Earth are correct? Select two answers.

(A) The satellite's kinetic energy is constant throughout the orbit.
(B) The satellite's angular momentum about the center of mass of the satellite-Earth system is constant throughout the orbit.
(C) The magnitude of the satellite's linear momentum is constant throughout the orbit.
(D) The gravitational potential energy of the Earth-satellite system is greatest at the satellite's farthest point from Earth.

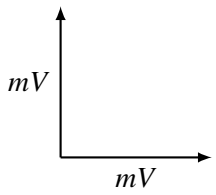
21. Which of the following can be used as evidence for the claim that the energy carried by a mechanical wave increases with the amplitude of the wave? Select two answers.

(A) A person does not move when a small ocean wave passes by but is pushed over by a higher wave.
(B) A high-pitched sound may cause more discomfort to a person's ear than a low-pitched sound does.
(C) The interference of two waves of amplitude A_0 may result in an amplitude that is either larger or smaller than A_0.
(D) A wave pulse on a string is larger or smaller, depending on how far the person creating the pulse moves the end of the string.



22. A rod on a horizontal tabletop is pivoted at one end and is free to rotate without friction about a vertical axis, as shown above. A force **F** is applied at the other end, at an angle θ to the rod. If **F** were to be applied for the rod, at what distance from the axis should it be applied in order to produce the same torque?

(A) $L \sin\theta$
(B) $L \cos\theta$
(C) L
(D) $L \tan\theta$
(E) $\sqrt{2}L$

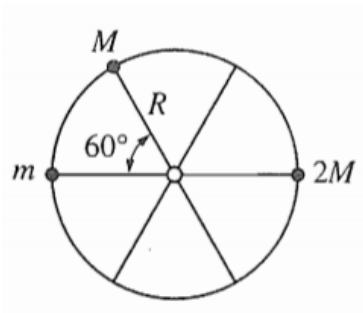


23. A stationary object explodes, breaking into three pieces of masses m, m and $3m$. The two pieces of mass m move off at right angles to each other with the same magnitude of momentum mV, as shown in the diagram above. What are the magnitude and direction of the velocity of the piece having mass $3m$?

	Magnitude	Direction
(A)	$\frac{V}{\sqrt{3}}$	↗
(B)	$\frac{V}{\sqrt{3}}$	↙
(C)	$\frac{\sqrt{2}V}{3}$	↗
(D)	$\frac{\sqrt{2}V}{3}$	↙
(E)	$\sqrt{2}V$	↙

24. An old record player could bring a disk up to 45 rpm speed in less than a second. If the same size disk can also be brought up to a speed of 75 rpm in about the same amount of time on another player, compare the two torques.

(A) The torques would be the same as the amount of rotational inertia of the two disks are the same.
(B) The torques would be the same because of the conservation of angular momentum.
(C) The torque would be larger in the second case as it requires a greater angular acceleration.
(D) The torque would be larger in the second case as it entails both a larger force and a larger lever arm.

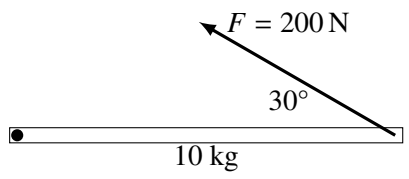


25. A wheel of radius R and negligible mass is mounted on a horizontal frictionless axle so that the wheel is in a vertical plane. Three small objects having masses m, M and $2M$, respectively, are mounted on the rim of the wheel, as shown above. If the system is in static equilibrium, what is the value of m in terms of M?

(A) $\frac{M}{2}$
(B) M
(C) $\frac{3M}{2}$
(D) $2M$
(E) $\frac{5M}{2}$

26. A 2 kg object moves in a circle of radius 4 m at a constant speed of 3 m/s. A net force of 4.5 N acts on the object. What is the angular momentum of the object with respect to an axis perpendicular the circle and through its center?

(A) $9\,\mathrm{N \cdot m/kg}$
(B) $12\,\mathrm{m^2/s}$
(C) $13.5\,\mathrm{kg \cdot m^2/s^2}$
(D) $18\,\mathrm{N \cdot m/kg}$
(E) $24\,\mathrm{kg \cdot m^2/s}$



27. What is the net torque acting on the pivot supporting a 10 kg beam 2 meters long as shown above?

(A) $198\,\mathrm{N \cdot m}$
(B) $-198\,\mathrm{N \cdot m}$
(C) $-102\,\mathrm{N \cdot m}$
(D) $102\,\mathrm{N \cdot m}$

Question 28–29 A 0.4 kg mass is oscillating on a spring that has a force constant of $k = 1000\,\mathrm{N/m}$.

28. Which of the following measurements would allow you to determine the maximum velocity experienced by the mass?

(A) No additional information is required.
(B) Minimum velocity
(C) Maximum acceleration
(D) None of these would allow you to determine maximum velocity

29. Which of the following statements concerning the oscillatory motion described is correct? (All statements refer to magnitudes.)

(A) The maximum velocity and maximum acceleration occurs at the same time.
(B) The maximum velocity occurs when the acceleration is a minimum.
(C) The velocity is always directly proportional to the displacement.
(D) The maximum velocity occurs when the displacement is a maximum.

30. Cylindrical disk A is rotating freely about an axis when an identical disk B that is not rotating is dropped directly on top of disk A. If the two disks stick together, how does the total angular momentum and total kinetic energy of the two-disk system after the disks are stuck together compare to that of the system before disk B was dropped?

	Total Angular Momentum	Total Kinetic Energy
(A)	Remains the same	$\frac{1}{2}$ its original value
(B)	Remains the same	$\frac{1}{4}$ its original value
(C)	$\frac{1}{2}$ its original value	$\frac{1}{2}$ its original value
(D)	$\frac{1}{2}$ its original value	$\frac{1}{4}$ its original value