

Sample Physics Challenge

Directions: Each set of lettered choices below refers to the numbered questions immediately following it. Select the one lettered choice that *best* answers each question, and then fill in the corresponding oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-3 refer to two marbles that are released next to each other, at the same time, from the same height above the ground. One marble is shot horizontally from a spring gun; the other is dropped from rest. Air resistance and the curvature of the Earth are negligible and g , the acceleration due to gravity, is constant for both balls and directed perpendicular to the ground.

- (a) The marble that is shot
- (b) The marble that is dropped
- (c) It is a tie
- (d) It cannot be determined without knowing the height.
- (e) It can not be determined without knowing the value of g .

1. If the marbles are identical, which one hits the ground first?
2. If the marbles are identical, which one hits the ground with the greater speed?
3. If the dropped marble has twice the mass of the shot marble, which marble hits the ground first?
4. A rock weighing 10 N is lifted 10 m from the ground, and then dropped on a wooden stake, thus driving it into the ground. The work done by the rock in driving the stake into the ground is most nearly

- (a) 0:01 J
- (b) 0:1 J
- (c) 1 J
- (d) 100 J
- (e) It can not be determined without knowing the value of the gravitational acceleration, g .

5. “Crushing a 50-gallon drum:” a large tin barrel at room temperature (300 K) is closed with a lid (which is not air-tight) and heated to 400 K. Then the lid is sealed shut, and the barrel is quickly cooled (by rubbing its surface with ice) back to 300 K. The difference between the atmospheric pressure and the pressure inside the barrel will overwhelm the barrel walls and crumble them. If the atmospheric pressure is 100 kPa (= 100 kN/m²), and the surface of the barrel has an area of 1m², what is the total force on the surface of the barrel just before it is crushed?
- (a) 25 kN
 - (b) 75 kN
 - (c) 100 kN
 - (d) 133.3 kN
 - (e) 400 kN

Questions 6-7 refer to five objects that are moving in parallel straight-line paths. The objects all cross a starting line at the instant a clock is started. The distance from the starting line in meters after 1, 2, 3, 4, and 5 seconds are as follows:

Object	1 s	2 s	3 s	4 s	5 s
(a)	1 m	1 m	2 m	2 m	3 m
(b)	1 m	2 m	3 m	4 m	5 m
(c)	1 m	4 m	9 m	16 m	25 m
(d)	4 m	10 m	18 m	28 m	40 m
(e)	6 m	11 m	15 m	18 m	20 m

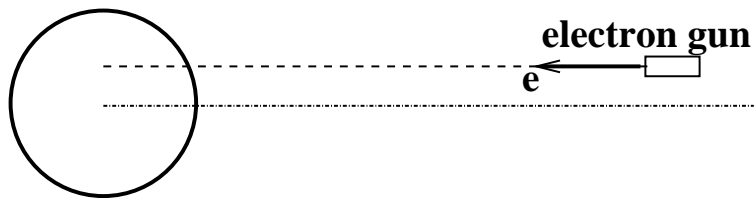
6. Which object is moving with zero acceleration?
7. Which object has constant nonzero acceleration and appears to have started from rest?
8. As a child wearing wool pants slides down a plastic slide, gravitational potential energy may be converted to which of the following?
- I. Thermal energy
 - II. Kinetic energy
 - III. Electrostatic potential energy
- (a) I only
 - (b) II only
 - (c) I and III only
 - (d) II and III only
 - (e) I, II, and III

9. A pot with 1 kg of soup at room temperature (300 K) is put on a hot plate. The resistance of the hot plate is 10Ω , and it is connected to the wall outlet with the voltage of 100 V. The hot plate is old and only 50% of the heat generated in the hot plate is transmitted to the soup. The specific heat of soup is 4 kJ/(kg K). How long does it take to bring the soup to a boil? (Assume that the soup is not losing heat after it has been warmed-up, and that it will boil at 360 K.)
- (a) 1 minute
 (b) 3.5 minutes
 (c) 4 minutes
 (d) 7 minutes
 (e) 8 minutes
10. A Hopkins physics major is helping in a kitchen of a Baltimore restaurant over the summer. A recipe for a sauce calls for heating two cups of the sauce mixture in a saucepan, and adding one cup of the mixture later. The student is bored and starts wondering whether the ultimate temperature of the sauce (once everything is added) will depend on when the additional content is poured into the saucepan. In all cases the saucepan is being heated for the same amount of time. The student concludes that the temperature of the sauce will be the highest when
- (a) the cup is poured immediately and all three cups of sauce are heated together
 (b) the cup is added at the end, once two cups of sauce are heated to even higher temperature
 (c) half of the cup's content is added immediately, and the other half is added at the end
 (d) the content of the cup is poured gradually
 (e) it does not matter – the ultimate temperature of the sauce does not depend on when the third cup is added to the saucepan
11. A satellite moving in a circular orbit with respect to the Earth's center experiences a gravitational force. If the radius of the orbit is decreased, how will the gravitational force and the speed of the satellite change, if at all?

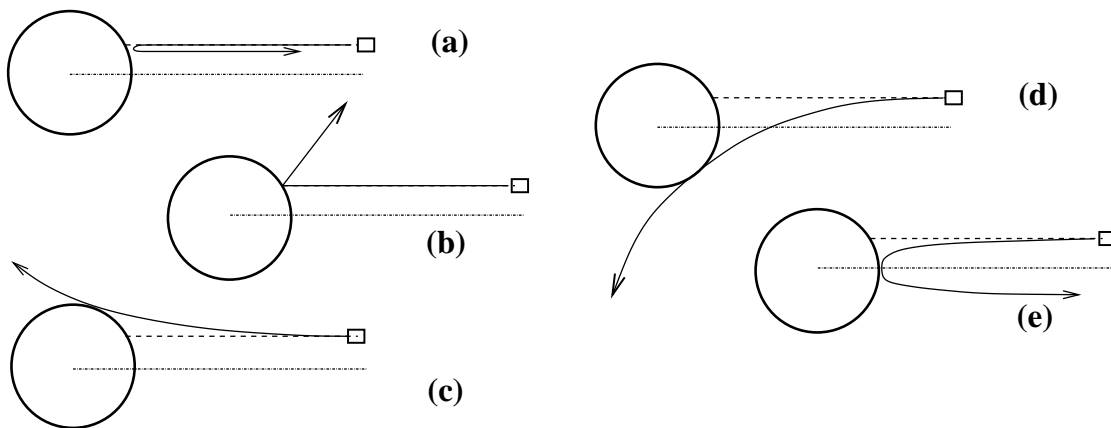
	Gravitational Force	Velocity
(a)	Decrease	Decrease
(b)	Decrease	Increase
(c)	Remain the same	Remain the same
(d)	Increase	Decrease
(e)	Increase	Increase

- 12.** If the temperature of an ideal gas increases, one can be certain that which of the following also increases?
- (a) The average kinetic energy of the gas molecules
 - (b) The rest mass of each gas molecule
 - (c) The volume occupied by the gas
 - (d) The pressure exerted by the gas
 - (e) The number of moles of the gas
- 13.** A person normally weighing 500 N steps on a bathroom scale in an elevator. If later the scale reads 450 N, this indicates that the elevator is
- (a) moving downward with a constant velocity
 - (b) accelerating downward
 - (c) moving upward with a constant velocity
 - (d) accelerating upward
 - (e) at rest
- 14.** The colors seen in a soap bubble are primarily due to
- (a) polarization
 - (b) interference
 - (c) absorption
 - (d) fluorescence
 - (e) phosphorescence

15. A metal sphere of radius 10 cm is suspended in vacuum and fixed. Electrons are being shot, one at a time, from the distance of 5 m towards the sphere, in the direction which is off-axis by 5 cm and with the initial velocity of 1000 m/s. The sphere is thus slowly being charged.



Which of the figures below describes the trajectory of the electrons when the charge on the sphere reaches the maximum value?

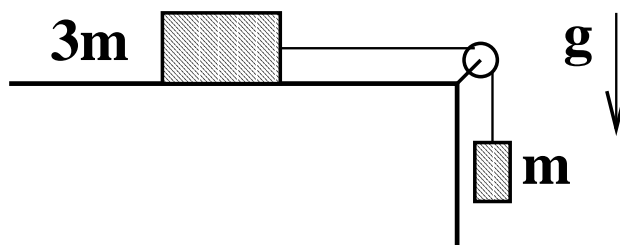


16. A hollow metal sphere that has a diameter of 50 centimeters has a positive charge of 8×10^{-5} C. The electric field at the center of the sphere has a magnitude of

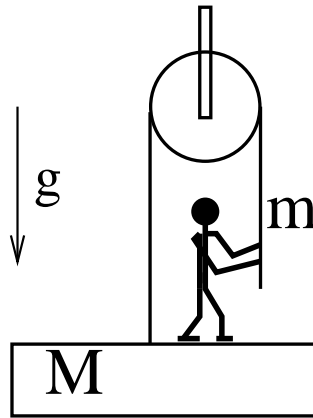
- (a) 0 N/C
- (b) 3.2×10^{-4} N/C
- (c) 6.4×10^{-4} N/C
- (d) 1.28×10^{-3} N/C
- (e) 6.4×10^6 N/C

17. A block of mass $3m$ can move without friction on a horizontal table. This block is attached to another block of mass m by a cord that passes over a frictionless pulley, as shown on the figure. If the masses of the cord and pulley are negligible, what is the magnitude of the acceleration of the descending block?

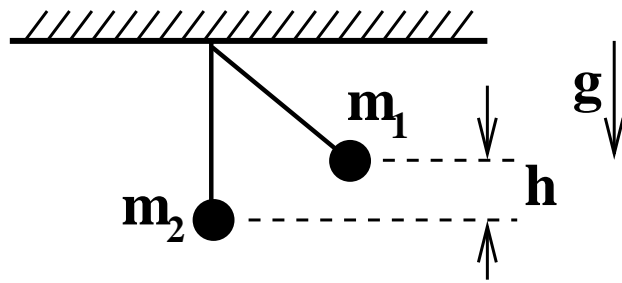
- (a) Zero
- (b) $g/4$
- (c) $g/3$
- (d) $2g/3$
- (e) g



18. A platform of mass M is attached to a rope which goes up over a pulley and hangs down freely. A man of mass m stands on the platform and pulls the rope to lift himself and the platform at a constant speed, as shown in figure below. What force does the man exert on the rope? (g is the acceleration due to gravity).



- (a) Mg
 - (b) $(M + m)g$
 - (c) $(M - m)g/2$
 - (d) $(M + m)g/2$
 - (e) $(M - m)g$
19. Two small objects of masses m_1 and m_2 are suspended from massless, unstretchable strings of equal length. The object with mass m_1 is raised to a height h as shown on figure and released. If the objects stick together after colliding, they will swing on the other side to a height that is

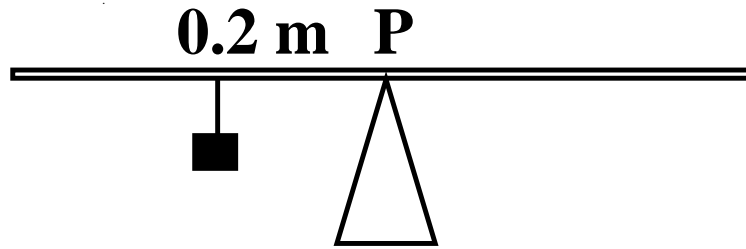


- (a) greater than h
 - (b) equal to h
 - (c) less than h
 - (d) greater than, equal to, or less than h , depending on the value of h
 - (e) greater than, equal to, or less than h , depending on the ratio m_2/m_1
20. The curvature of Mars is such that two people, 2.0 meters tall each, would not see each other if they were standing 7200 meters away from each other (their heads would be just below the horizon relative to the other person's line of sight). In addition, the gravitational acceleration near its surface is 0.4 times that near the surface of Earth. What is the speed a golf ball would need to orbit Mars just near the surface, ignoring the effects of air resistance?

- (a) 0.9 km/s
- (b) 1.8 km/s
- (c) 3.6 km/s
- (d) 4.5 km/s
- (e) 5.4 km/s

21. A massless rod is supported at point P as shown on figure. A block weighing 40 N is attached to the rod at 0.2 m from P . How far from P must a block weighing 80 N be attached in order to balance the rod?

- (a) 0.1 m
- (b) 0.2 m
- (c) 0.4 m
- (d) 0.5 m
- (e) 0.8 m

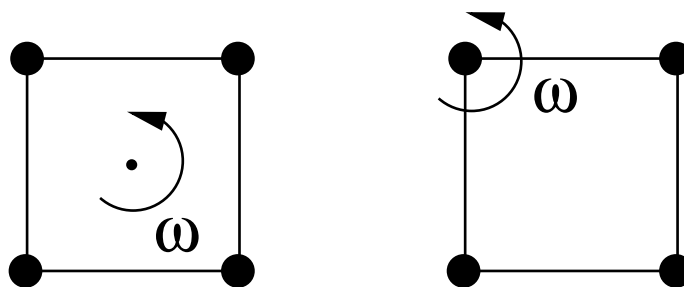


22. Two metal spheres of equal radius are each charged and mounted on insulated stands. Sphere 1 has a charge of $+20\text{ C}$; sphere 2 has a charge of -4 C . The two spheres are touched together and then separated. The charge on sphere 2 will now be

- (a) 0
- (b) $+4\text{ C}$
- (c) $+8\text{ C}$
- (d) $+16\text{ C}$
- (e) $+20\text{ C}$

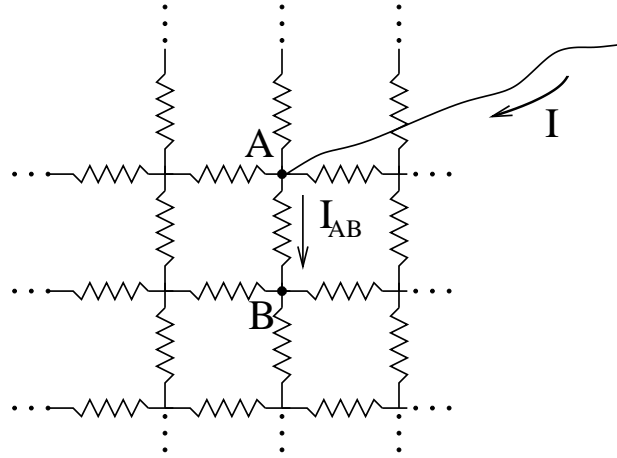
23. Four equal masses m are rigidly connected to each other by massless rods forming a square. The assembly is to be given an angular velocity ω about an axis perpendicular to the square. For fixed ω , the ratio of the kinetic energy of the assembly for an axis through one corner compared with that for an axis through the center is equal to

- (a) 4
- (b) 1
- (c) $1/2$
- (d) $1/3$
- (e) $1/4$



24. Resistors of resistance R are arranged into an infinite planar quadratic grid, as shown in figure below. One terminal of an external circuit is connected to a point A. The other terminal is infinitely far away from A. The current I flows into the grid at the point A, and divides between the four resistors connected to it. What is the current I_{AB} through the resistor that connects A and B?

- (a) $I/2$
 (b) $I/4$
 (c) $I/8$
 (d) $I/16$
 (e) cannot be determined without knowing the value of R



25. Resistors of resistance R are arranged into an infinite planar quadratic grid, as shown in figure below. The terminals of an external circuit are connected to ends of one resistor, at points A and B. The current I flows into the grid at the point A and flows out at the point B. What is the current I_{AB} through the resistor that connects A and B?

- (a) $I/2$
 (b) $I/4$
 (c) $I/8$
 (d) $I/16$
 (e) cannot be determined without knowing the value of R

