

Physics Prize 2015 (Part I)

1. A rectangle is 3.245 m long and 1.5 m wide. What is its area in square meters? Choose the answer with the correct number of significant figures.
 - a) 4.8675
 - b) 4.868
 - c) 4.87
 - d) 4.9 *
 - e) 4.0
2. Objects A and B both start from rest. Object A's acceleration is twice as large as that of object B. If they travel the same distance, what is the ratio of object A's travel time to object B's travel time (t_A/t_B)?
 - a) 1/2
 - b) $1/\sqrt{2}$ *
 - c) 1
 - d) 2
 - e) 4
3. A car is slowing down with constant deceleration while moving in the positive x -direction. The velocity versus time graph is:
 - a) a straight horizontal line
 - b) a straight vertical line
 - c) a straight line with a negative slope *
 - d) a straight line with a positive slope
 - e) a parabola
4. A stone is thrown downward from a tall cliff with a speed of 10 m/s. The distance travelled by the stone in the third second of the fall is about
 - a) 162 m
 - b) 122 m
 - c) 85 m
 - d) 35 m *
 - e) 14 m
5. Vector \mathbf{A} has components $A_x = 5$ and $A_y = -8$ in a rectangular x - y coordinate system. The magnitude of vector $-2\mathbf{A}$ is about
 - a) 6
 - b) 9
 - c) 12
 - d) 19 *
 - e) 30
6. A projectile is shot horizontally at 23.4 m/s from the roof of a building 55.0 m tall. The vertical component of the projectile's velocity just before it reaches the ground is about
 - a) 32.8 m/s *
 - b) 68.3 m/s
 - c) 23.4 m/s
 - d) 3.35 m/s
 - e) 0 m/s

7. A book of mass m lies on a flat surface. The weight of the book is the force with which the Earth pulls on the book. If the weight is the action force, what is the reaction force according to Newton's third law?
- the table pushing up on the object with force mg
 - the object pushing down on the surface with force mg
 - the surface pushing down on the Earth with force mg
 - the book pulling on the Earth with force mg *
 - the static friction between the book and the surface
8. A car takes a 500-m radius curve on a highway. If the coefficient of static friction between the tires and the road is 0.15, what is the maximum speed of the car before it starts slipping?
- not enough information – the coefficient of kinetic friction is needed
 - not enough information – the mass of the car is needed
 - 27.1 m/s *
 - 103 m/s
 - 735 m/s
9. A mass of 500 g takes 2.0 s to slide down an inclined plane of angle 18° . What time does a mass of 125 g take to travel the same distance if all other parameters (including the coefficient of kinetic friction) remain the same?
- 0.5 s
 - 1.0 s
 - 2.0 s *
 - 4.0 s
 - 8.0 s
10. A wheel starts from rest and reaches an angular speed of 6.0 rad/s while turning through 2.0 revolutions. The average angular acceleration of the wheel is about
- 0.45 rad/s²
 - 1.4 rad/s² *
 - 3.0 rad/s²
 - 6.8 rad/s²
 - 9.0 rad/s²
11. When a ball of mass m rises vertically to a height h and then returns to its original position, the work done by the gravitational force is:
- $+ 2 m \cdot g \cdot h$
 - $- 2 m \cdot g \cdot h$
 - $+ m \cdot g \cdot h$
 - $- m \cdot g \cdot h$
 - 0 *
12. A roller coaster starts with a speed of 5.0 m/s at a point 45 m above the ground. Neglecting friction, the speed of the roller coaster at the top of the next slope, which is 30 m above the ground will be about
- not enough information – the mass of the roller coaster is needed
 - 18 m/s *
 - 12 m/s
 - 5.0 m/s
 - 0 m/s

13. A 4.0-kg particle is moving horizontally with a speed of 5 m/s when it hits a vertical wall. The particle rebounds with a speed of 5.0 m/s. What is the magnitude of the impulse delivered to the particle by the wall?
- 40 N·s *
 - 32 N·s
 - 20 N·s
 - 5 N·s
 - 0 N·s
14. Two ice skaters of masses $m_1 = 60$ kg and $m_2 = 45$ kg skate toward each other with speeds $v_1 = 4.0$ m/s and $v_2 = 3.0$ m/s, respectively. They collide head-on and stick together. The speed at which they will move off together is about
- 1.0 m/s *
 - 2.5 m/s
 - 3.6 m/s
 - 4.8 m/s
 - 0 m/s
15. A plane, flying horizontally, releases an object, which explodes into three fragments before hitting the ground. Neglecting air resistance, what is the trajectory of the center of mass of the fragments just after the explosion?
- a straight horizontal line
 - a straight vertical line
 - a straight line with negative slope
 - a parabolic path *
 - the center of mass remains stationary
16. A heavy boy and a light girl are balanced on a seesaw. If they both move away from the pivot point so that they are twice their original distances from the pivot point, what will happen?
- it depends on who is sitting on the left side and who is sitting on the right side
 - not enough information – their masses need to be known
 - the side the boy is sitting on will tilt downward
 - the side the girl is sitting on will tilt downward
 - nothing – they will still be balanced *
17. A wheel of moment of inertia $4.5 \text{ kg} \cdot \text{m}^2$ starts spinning about its axis from rest, accelerating under a constant torque of $3.0 \text{ N} \cdot \text{m}$ for 8.0 s. What is the wheel's rotational kinetic energy at the end of the 8.0 s?
- 24 J
 - 57 J
 - 64 J *
 - 88 J
 - 95 J
18. An ice skater performs a pirouette (a fast spin) by pulling in her outstretched arms close to her body. Her angular speed during the spin increases as she pulls her arms in because of:
- conservation of mass
 - conservation of energy
 - conservation of linear momentum
 - conservation of angular momentum *
 - the law of universal gravitation

19. The acceleration of gravity on the Moon is one-sixth what it is on Earth. If the mass of the Moon is $1/96$ of the mass of the Earth, what is the ratio of the Moon's radius to Earth's radius?
- a) $1/96$
 - b) $1/6$
 - c) $1/4$ *
 - d) $1/2$
 - e) 1
20. A 1.0-kg piece of aluminum and a 1.0-kg piece of lead sit at the bottom of a lake. Which one has the greater buoyant force on it? The density of lead is higher than the density of aluminum.
- a) the aluminum piece *
 - b) the lead piece
 - c) the buoyant forces are the same
 - d) not enough information – the shapes of the pieces need to be known
 - e) there is no buoyant force on either of them because they are not floating
21. A block of mass 1.5 kg floats in water. If 25% of its volume is below the waterline, what is the volume of the object? The density of water is 1000 kg/m^3 .
- a) $1.0 \times 10^{-6} \text{ m}^3$
 - b) $2.0 \times 10^{-3} \text{ m}^3$
 - c) $6.0 \times 10^{-3} \text{ m}^3$ *
 - d) $4.0 \times 10^3 \text{ m}^3$
 - e) $4.0 \times 10^6 \text{ m}^3$
22. Due to a fatty plaque, the radius of a blood vessel decreases by 80%. How does the velocity of blood through the vessel change? Treat blood as an incompressible ideal fluid (density is constant and viscous friction is ignored).
- a) increases 25 times *
 - b) decreases 25 times
 - c) increases 5 times
 - d) decreases 5 times
 - e) remains the same
23. Two simple pendula, A and B, swing with the same period in the gravitational field of the Earth. However, the amplitude of A is three times larger than the amplitude of B. Which of the following statements has to be correct?
- a) the two pendula have the same mass
 - b) the two pendula have the same length *
 - c) the length of pendulum A is three times the length of pendulum B
 - d) the length of pendulum A is one third the length of pendulum B
 - e) the mass of pendulum A is three times the mass of pendulum B
24. Ocean waves with a wavelength of 60 m are coming in at a rate of 9 per minute. What is their speed of propagation?
- a) 6.7 m/s
 - b) 9.0 m/s *
 - c) 29 m/s
 - d) 60 m/s
 - e) $5.4 \times 10^2 \text{ m/s}$

25. A police car has an 800-Hz siren. The car approaches a stationary pedestrian at a speed of 35 m/s. What change of frequency due to the Doppler effect does the pedestrian hear? Take the speed of sound to be 340 m/s.

- a) 92 Hz *
- b) 75 Hz
- c) 58 Hz
- d) 23 Hz
- e) 11 Hz