Worldwide Youth in Science and Engineering

2012 Academic Challenge

PHYSICS TEST - SECTIONAL

This Test Consists of 35 Questions

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GENERAL DIRECTIONS

Please read the following instructions carefully. This is a timed test; any instructions from the test supervisor should be followed promptly.

The test supervisor will give instructions for filling in any necessary information on the answer sheet. Most Academic Challenge sites will ask you to indicate your answer to each question by marking an oval that corresponds to the correct answer for that question. Only one oval should be marked to answer each question. Multiple ovals will automatically be graded as an incorrect answer.

Be sure ovals are marked as ● , not ⊙ , ◐ , ◑ , etc.

If you wish to change an answer, erase your first mark completely before marking your new choice.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not waste your time on questions that seem too difficult for you. Go on to the other questions, and then come back to the difficult ones later if time remains.

***** TIME: 40 MINUTES *****

DO NOT OPEN TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO!

Fundamental Constants

Quantity	Symbol	Value
Avogadro's number	N_A	6.022×10^{23}/mol
Boltzmann's constant	k	1.381×10^{-23} J/K
Electron charge magnitude	e	1.602×10^{-19} C
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T·m/A
Permittivity of free space	ε_0	8.854×10^{-12} C^2/(N·m^2)
Planck's constant	h	6.626×10^{-34} J·s
Electron mass	m_e	9.1094×10^{-31} kg
Neutron mass	m_n	1.6749×10^{-27} kg
Proton mass	m_p	1.6726×10^{-27} kg
Speed of light in vacuum	c	2.9979×10^{8} m/s
Universal gravitational constant	G	6.673×10^{-11} N·m^2/kg^2
Universal gas constant	R	8.3145 J/(mol·K)

Other information:

Acceleration due to gravity at earth's surface: g = 9.80 m/s^2

0.00 ^{o}C = 273.15 K

WYSE – Academic Challenge
Physics Test (Sectional) – 2012

1. Two gnats sit, without slipping, on a horizontal turntable which is rotating at constant angular speed. Gnat "B" has 2.00 times the orbital radius and 1.50 times the mass that gnat "A" has. The centripetal force acting on gnat "B" to that acting on gnat "A" is

   a. 2.00 to 1.00.
   b. 12.0 to 1.00.
   c. 6.00 to 1.00.
   d. 3.00 to 4.00.
   e. 3.00 to 1.00.

2. An elevator on earth and a woman riding in the elevator are accelerating downward at the rate of 1.25 m/s^2. What is the apparent weight of the woman if her actual weight is 387 N?

   a. 436 N b. 338 N c. 49.4 N d. 96.8 N e. 871 N

3. Just before a golf ball sized hail hits an automobile's windshield, the hail's velocity is 25.0 mph vertically downward relative to Earth. At that instant, relative to Earth, the automobile is traveling 60.0 mph in the horizontal direction. What is the speed of the hail relative to the automobile?

   a. 35.0 mph b. 25.0 mph c. 85.0 mph d. 65.0 mph e. 54.5 mph

4. A diver runs horizontally off the end of a platform that is 5.00 m above the water's surface. If the horizontal speed of the diver upon leaving the platform is 1.75 m/s, what is the speed of the diver when the diver's center of gravity has fallen a vertical distance of 4.00 m?

   a. 8.85 m/s b. 9.03 m/s c. 11.9 m/s d. 78.4 m/s e. 6.26 m/s

5. How long does it take the diver's center of gravity to fall the 4.00 m vertical distance mentioned in problem 4?

   a. 0.443 s b. 0.742 s c. 0.639 s d. 0.816 s e. 0.904 s

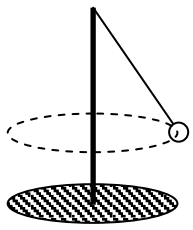
6. A caretaker mows a lawn with a push mower, exerting a force of 234 N directly along the handle of the 19.7 kg mower. If the handle makes an angle of 37.0^o with the horizontal lawn surface, what is the normal force exerted by the lawn on the mower?

   a. 254 N b. 427 N c. 334 N d. 161 N e. 380. N

7. Which of the following have an equivalent set of units?
   i. power ii. impulse iii. force iv. work v. momentum

   a. i. and iv. b. ii. and iii. c. ii. and v. d. iii. and iv. e. i. and ii.

8. After a tether ball is hit, it begins to move in a horizontal, circular orbit about the pole, as indicated in the diagram. Assuming that friction is negligible, the net force on the tether ball, after it has been hit, is



   a. along the tether ball's cord directed toward the top of the pole.
   b. straight down toward the ground.
   c. tangent to the circular orbit in the direction the ball is moving at that instant.
   d. toward the center of the tether ball's circular orbit.
   e. vertically upward.

9. A 0.225 g bumblebee is sitting on one end of a 5.775 g pencil that is floating and at rest in a sink of water. The bumblebee then begins to run along the pencil, causing the pencil to move in the opposite direction with a constant speed of 0.188 cm/s relative to the sink. Assuming that water and air resistance are negligible, how fast is the bumblebee running relative to the sink while the pencil has this speed?

   a. 4.83 cm/s
   b. 0.00732 cm/s
   c. 5.01 cm/s
   d. 0.181 cm/s
   e. 0.952 cm/s

10. A certain centrifuge is rotated at 875.0 rad/s. What is the rotation rate in rpm?

    a. 8356 b. 3.299×10^5 c. 91.63 d. 2.321 e. 139.3

11. A vertically oriented, thin rod of mass 2.64 kg is pinned at its lower end so that the rod is free to rotate in a vertical plane with the pin as axis. The moment of inertia of the rod about this axis is $0.563\ \text{kg}\cdot\text{m}^2$, and the center of gravity of the rod is 0.400 m above this axis. As the rod turns on this axis, it experiences a frictional torque equal to $1.20\ \text{N}\cdot\text{m}$. If the rod is given a small nudge to initiate motion from the vertical orientation, what will its angular speed be when it is horizontally oriented?

    a. 5.48 rad/s b. 6.06 rad/s c. 5.70 rad/s d. 18.4 rad/s e. 15.0 rad/s

12. A uniform meter stick balances at its geometric center. When a small chain is hung from one end of this meter stick, the balance point of the chain-stick system moves 12.0 cm toward that end. The mass of the chain divided by the mass of the stick is

    a. 0.120 b. 4.17 c. 0.194 d. 0.316 e. 0.806

13. Two bird watchers are listening to the song from a nearby bird. One of the watchers is 4.35 m away from the bird and experiences a sound intensity of $3.00 \times 10^{-6}\ \text{W/m}^2$ for one of the bird's notes. If the sound intensity of the same note experienced by the other watcher is $7.34 \times 10^{-7}\ \text{W/m}^2$, how far away from the bird is this watcher, assuming that there is no reflected sound from any surface?

    a. 4.22 m b. 8.79 m c. 17.8 m d. 72.7 m e. 8.52 m

14. Two speakers are emitting a tone of frequency *f* and are in phase with one another. A person is 3.000 m from one of the speakers and 3.750 m from the other. If the speed of sound in air is 343 m/s, what is the minimum value of *f* that results in constructive interference for the person?

    a. 229 Hz b. 915 Hz c. 172 Hz d. 102 Hz e. 457 Hz

15. When a 45.0 kg child stands on a certain beachball pressing it against a sidewalk, the circular area of contact between the bottom of the beachball and the concrete below it has a radius of 4.65 cm. Assuming that the weight of the beachball is negligible, what is the gauge pressure of the air in the beachball?

    a. 1.62×10^4 Pa
    b. 1.66×10^3 Pa
    c. 6.49×10^4 Pa
    d. 1510 Pa
    e. 6.62×10^3 Pa

16. A 321 g lead cube, initially at a temperature of 78.0 ^{o}C, is placed in an insulated vessel containing 175 g of water at 23.0 ^{o}C. Given that the specific heat of water is 32.70 times that of lead, and assuming that no heat is exchanged with the vessel, what is the final temperature of the water-lead system?

a. 25.9 ^{o}C b. 17.6 ^{o}C c. 77.1 ^{o}C d. 58.6 ^{o}C e. 24.6 ^{o}C

17. A Carnot heat pump is used to heat a room that is at 23.0 ^{o}C. After the heat pump has done 384 J of work, how much heat has been delivered to the room if the outdoor temperature is –5.00 ^{o}C?

a. 315 J b. 4.06 kJ c. 3.68 kJ d. 424 J e. 1.69 kJ

18. A charge of 5.69×10^{-8}C is fixed on the origin of a coordinate system. A second charge of -9.18×10^{-8}C is fixed on the x axis at location x = 0.750 m. At which of the following points on the x axis would the electric potential be zero?

a. 1.21 m b. –0.465 m c. 0.465 m d. –2.22 m e. 0.287 m

19. In the situation described in problem 18, what is the *x* component of the electric field at the position on the *x* axis at *x* = 0.500 m?

a. –2.28 kN/C b. 4.32 kN/C c. 11.2 kN/C d. −11.2 kN/C e. 15.2 kN/C

20. A car starts from rest and then initially moves directly east along a 200. m radius circular path. After the car has travelled one-fourth of a lap around the path, the car is headed directly north. If the car has travelled this distance in 10.0 s, what is the average velocity of the car?

a. 5.00 m/s 45° north of east
b. 14.1 m/s 45° north of east
c. 28.3 m/s 45° north of east
d. 31.4 m/s 45° north of east
e. As the magnitude of the acceleration is not necessarily constant, this problem cannot be solved.

21. In problem 20, what is the average speed of the car during the motion described?

a. 5.00 m/s
b. 14.1 m/s
c. 28.3 m/s
d. 31.4 m/s
e. As the magnitude of the acceleration is not necessarily constant, this problem can't be solved.

22. Vector **A** is 5.00 units in length and points directly east. Vector **B** is 4.00 units in length and points in the direction 36.87° south of east. What is vector **C** = **A** − **B**?

a. Vector **C** is 1.00 unit long and points in the direction directly east.
b. Vector **C** is 3.00 units long and points in the direction 36.9° north of east.
c. Vector **C** is 3.00 units long and points in the direction 53.1° north of east.
d. Vector **C** is 8.54 units long and points in the direction 16.3° south of east.
e. Vector **C** is 8.54 units long and points in the direction 73.7° south of east.

23. A locomotive pulling two freight cars of equal mass m is able to accelerate at 1.00 m/s^2 under full-throttle force on a level track. The same locomotive pulling three freight cars of equal mass m is able to accelerate at 0.800 m/s^2 under the same full-throttle force on a level track. If the same external frictional force acts on the train in both situations, what is the mass of the locomotive?

a. 0.800m b. 1.25m c. 1.88m d. 2.00m e. 2.33m

24. Two billiard balls on a billiards table collide with a coefficient of restitution 0.920. The first ball has a mass 0.300 kg and the second ball has a mass 0.350 kg. At a certain instant during the collision at which friction is negligible, the first ball has an acceleration 1.50 m/s^2 toward the west. What is the magnitude of the acceleration of the second ball at the same instant?

a. 1.18 m/s^2 b. 1.29 m/s^2 c. 1.43 m/s^2 d. 1.50 m/s^2 e. 1.75 m/s^2

25. A block slides up a frictionless inclined plane a distance 2.00 m along the plane. The block slows from a speed 3.00 m/s to 1.00 m/s as it slides the 2.00 m distance. What is the angle of incline above horizontal of the inclined plane?

a. 11.8° b. 24.1° c. 30.0° d. 22.2° e. 65.9°

26. In a particular situation, a time-dependent force, F, is applied to an object. The mathematical expression for the force as a function of time, t, is $F = At^3$. In the SI unit system, what are the units of the constant A?

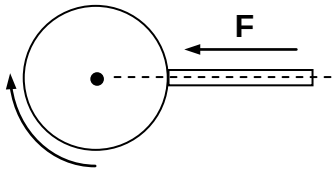
a. kg·m/s^5 b. N· s^3 c. N/s^2 d. kg·m/s^2 e. s^{-3}

27. A 4.00 N force acts toward the east on an 8.00 kg object as it moves 50.0 m in a straight line in a direction 30.0º east of north. How much work is done by the force on the object?

a. 100. J b. 125. J c. 150. J d. 173. J e. 200. J

28. A 24.0 cm diameter grinding wheel is attached to an electric motor. The motor acts with a clockwise torque of 5.00 N·m on the grinding wheel as the wheel rotates as shown in the diagram. A machinist pushes a piece of metal into the grinding wheel with a radial force **F** of magnitude 75.0 N. The angular velocity of the grinding wheel remains constant under these conditions. What is the coefficient of friction between the metal and the grinding wheel?

a. 0.140
b. 0.278
c. 0.440
d. 0.556
e. 0.800



29. A 60.0 kg student ascends a flight of stairs at constant speed, undergoing a vertical displacement of 8.00 m. If the power used to lift her body is 300.0 watts, how much time does she take to ascend the flight of stairs?

a. 1.14 s b. 1.60 s c. 8.45 s d. 12.1 s e. 15.7 s

30. One end of a massless spring with a 200. N/m spring constant is attached to a rigid wall and the other end is attached to a 3.00 kg mass that is otherwise free to slide on a level frictionless table. What magnitude force must be applied to the mass so that it will rest in static equilibrium while the spring is stretched 60.0 cm beyond its relaxed length?

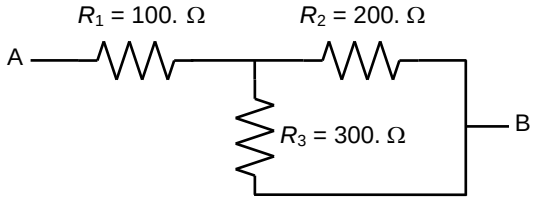
a. 1.80 N b. 3.33 N c. 120. N d. 180. N e. 12.0 kN

31. In the situation described in problem 30, the mass is released from rest at a position in which the spring is stretched 0.300 m beyond its relaxed length. How much time passes before the spring first reaches its relaxed length?

a. 0.100 s b. 0.192 s c. 0.385 s d. 0.770 s e. 0.900 s

32. For the given network of resistors, what is the resistance between terminals A and B?

a. 54.5 Ω
b. 150. Ω
c. 183. Ω
d. 220. Ω
e. 600. Ω



33. At some instant in time, the current in an inductor is zero but is increasing in the direction shown. Which statement about the voltage across the inductor is true at that instant?

a. The voltage at the right end of the inductor is greater than the voltage at the left end.
b. The voltage at the left end of the inductor is greater than the voltage at the right end.
c. The voltage at the left end of the inductor is equal to the voltage at the right end.
d. The rate of change of the voltage across the inductor is proportional to the rate of change of current.
e. The rate of change of the voltage across the inductor is proportional to the current.

34. A concave mirror has a radius of curvature 20.0 cm. At what distance from the mirror is the image of a point source located an infinite distance from the mirror on the optic axis of the mirror?

a. 20.0 cm
b. 10.0 cm
c. 40.0 cm
d. infinite distance
e. no image exists

35. The period of time that it takes for the activity of a sample of a radioactive isotope to decrease to 50% of its initial activity is called the isotope's

a. mean lifetime
b. decay constant
c. cross-section
d. atomic mass
e. half-life