Worldwide Youth in Science and Engineering

2012 Academic Challenge

PHYSICS TEST - REGIONAL

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 (Regional) – 2012

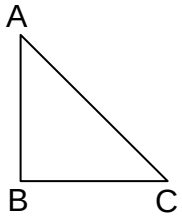
1. The average speed of an object is calculated by

   a. dividing the displacement of the object by the time for this displacement.
   b. dividing the distance traveled by the object by the time it takes for the object to travel this distance.
   c. dividing the straight line distance from the starting point to the ending point by the time it takes for the object to travel from the starting point to the ending point.
   d. using either a or b.
   e. using a, b, or c.

2. The SI unit of mass is the

   a. kilogram. b. Newton. c. dyne. d. pound. e. slug.

3. A conservative force acts on an object as it moves along the triangular closed path shown in the diagram. If the force does work *W* on the object as it moves directly from vertex A to adjacent vertex B, how much work does the force do on the object if it were to move from vertex A to vertex B by way of vertex C; i.e. from A to C to B?



   a. 0 b. –W c. 2W d. –2W e. W

4. From an inertial frame of reference an object that is not interacting with other objects

   a. would always be seen to have zero velocity.
   b. would always be seen to have zero acceleration.
   c. would always be seen to have an increasing velocity.
   d. could have any constant acceleration.
   e. would always be seen to have a decreasing velocity.

5. The impulse acting upon an object divided by the time the impulse acts is

   a. equal to the momentum of the object divided by the time the impulse acts.
   b. equal to the change in kinetic energy of the object.
   c. equal to the change in momentum of the object.
   d. equal to the average net force acting on the object.
   e. none of the above.

6. Two spacecraft, one with a mass of 3.50×10^3 kg and one with a mass of 2.50×10^3 kg, are coupled together and moving with a common velocity of 5.00 km/s in a certain direction. A separation blast then causes the two craft to separate such that the 3500 kg craft is moving 200. m/s faster than the 2500 kg craft, but with both craft still moving in the same direction. What is the new speed of the 2500 kg craft?

   a. 5.20 km/s b. 2.04 km/s c. 4.88 km/s d. 5.12 km/s e. 4.92 km/s

7. An object starts from rest. For the first 4.00 s, the object has an acceleration of 2.50 m/s^2 East. For the next 2.00 s, the object has an acceleration of 3.00 m/s^2 East. What is the speed of the object at the end of the 6.00 s?

   a. 26.0 m/s b. 33.0 m/s c. 8.00 m/s d. 16.5 m/s e. 16.0 m/s

8. For the same situation described in problem 7, how far has the object traveled during the 6.00 s?

   a. 46.0 m b. 26.0 m c. 48.0 m d. 49.5 m e. 74.0 m

9. A 5.00 kg mass slides back and forth undergoing simple harmonic motion as it slides on a frictionless, horizontal table surface. The restoring force for the mass is provided by a spring with negligible mass and spring constant 125.0 N/m. The amplitude of the mass's oscillation is 36.0 cm. When the mass reaches a point of zero velocity, what is the magnitude of the mass's acceleration?

   a. 9.00 m/s^2 b. 45.0 m/s^2 c. 4.50 m/s^2 d. 900. m/s^2 e. 1.62 m/s^2

10. For the situation described in problem 9, what is the stretch in the spring when the speed of the mass is 1.20 m/s?

    a. 0.312 m b. 0.0720 m c. 0.0576 m d. 0.268 m e. 0.240 m

11. A certain planet has mass *M*, radius *R*, and an acceleration due to gravity equal to *g* at its surface. Using symbol *G* for the universal gravitational constant, and assuming a constant density, which of the following expressions gives the value for the density of the planet?

    a. $\frac{g}{2\pi RG}$ b. $\frac{3g}{4\pi RG}$ c. $\frac{3g}{2\pi RG}$ d. $\frac{g}{4\pi RG}$ e. none of these

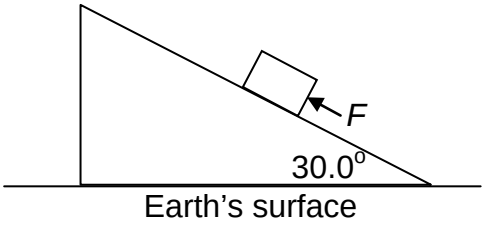
12. A mechanic, wearing ice cleats on his shoes to keep from slipping on a lake covered with a frictionless, horizontal sheet of ice, exerts a horizontal impulse on a 1500. kg automobile which is initially resting on the ice. The impulse causes the automobile to accelerate from rest to a speed of 1.52 m/s. What is the amount of the impulse delivered to the automobile by the mechanic?

    a. 649 Ns b. 987 Ns c. 1.73 kNs d. 1.14 kNs e. 2.28 kNs

13. In problem 12, how much work did the mechanic do on the automobile?

    a. 0.00 J
    b. 1.14 kJ
    c. 1.73 kJ
    d. 2.28 kJ
    e. 3.47 kJ

14. Force *F*, shown in the diagram, pushes a 128 kg box up a 30.0^o incline at constant speed. If a frictional force of 47.0 N exists between the box and the incline's surface, what is the value of *F*?



    a. 1.09 kN b. 111 N c. 674 N d. 1.13 kN e. 158 N

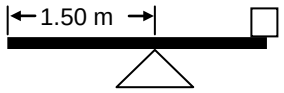
15. What is the coefficient of kinetic friction for the block-plane surface in problem 14?

a. 0.0433 b. 0.0375 c. 0.367 d. 0.424 e. 0.0749

16. Still considering problem 14, what is the efficiency of the incline plane, defined as: (the change in potential energy of the block) divided by (the work done by F)? Convert to a percentage.

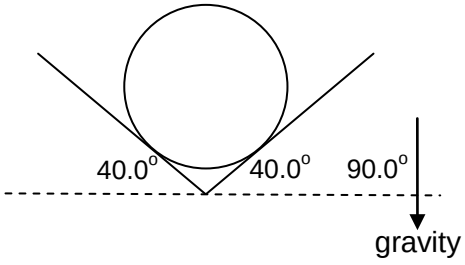
a. 95.9% b. 57.7% c. 70.2% d. 93.0% e. 100.%

17. A uniform density board has a mass of 20.0 kg and rests on a fulcrum that is 1.50 m from the left end of the board. A 5.00 kg mass rests with center of gravity at the right end of the board. If the board and mass are balanced on the fulcrum, what is the length of the board?



a. 2.00 m b. 2.40 m c. 5.00 m d. 2.50 m e. None of these.

18. A sphere having weight 148 N is supported by a V shaped trough with sides that make 40.0^o angles with a horizontal surface, as shown. What is the magnitude of the normal force that the left side of the trough exerts on the sphere?

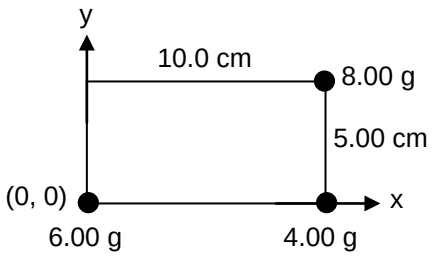


a. 88.2 N b. 115 N c. 74.0 N d. 193 N e. 96.6 N

19. After a speeder, moving at a constant speed of 19.0 m/s, has moved past a stationary police car by a distance of 45.6 m, the police car begins pursuit, traveling with a constant acceleration of 3.80 m/s^2. How long will it take the police car to catch the speeder under these conditions?

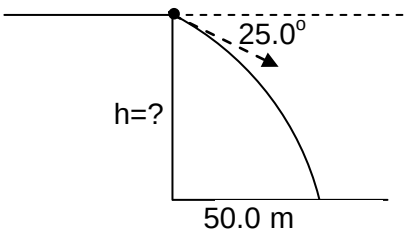
a. 10.0 s b. 4.90 s c. 12.0 s d. 34.0 s e. 1.11 s

20. Three small masses are attached to three corners of a uniform, rectangular board, as shown. If the mass of the board is 18.0 g, what is the x coordinate of the center of mass of the system?



a. 5.83 cm
b. 9.00 cm
c. 8.33 cm
d. 7.00 cm
e. 2.36 cm

21. A small stone is projected from a building with an initial speed of 40.0 m/s and at an angle of 25.0° below the horizon, as shown. If the stone first strikes the horizontal street below at a point 50.0 m from the base of the building, how tall is the building?



a. 9.32 m
b. 32.6 m
c. 150. m
d. 42.9 m
e. 57.7 m

22. A 2.34 kg object undergoes an acceleration given by $\vec{a} = \left(4.00\hat{i} + 5.00\hat{j}\right) \text{m/s}^2$. What is the magnitude of the force acting on the object?

a. 15.0 N b. 21.1 N c. 9.79 N d. 6.40 N e. 2.74 N

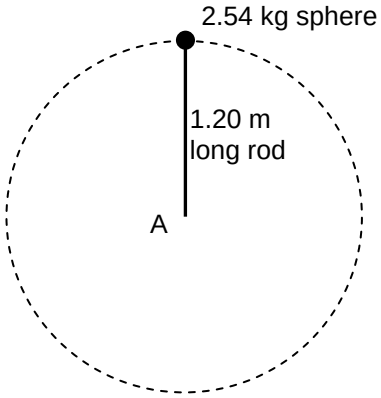
23. A student pushes horizontally on a physics book that is lying on the floor of an elevator, causing the book to move with constant speed across the elevator's rough, horizontal floor. In which of the following cases will she have to exert the greatest force?

a. The elevator moves downward with constant speed.
b. The elevator moves upward with constant speed.
c. The elevator accelerates downard.
d. The elevator accelerates upward.
e. More than one of the above would be correct.

24. A 0.150 kg rubber ball moving horizontally with a speed of 3.80 m/s rebounds from a wall and immediately after moves with the same speed in the opposite direction. If the contact time between ball and wall is 12.0 ms, what is the magnitude of the average force that the wall exerted on the ball?

a. 0.00 N b. 95.0 N c. 633 N d. 0.608 N e. 47.5 N

25. A 2.54 kg iron sphere is attached to one end of a 1.20 m long rigid rod which rotates about a fixed axis A at the other end of the rod . Thus the length of the rod serves as the radius of the sphere's planar orbit, as shown in the diagram. At some instant the sphere has a speed of 3.00 m/s tangent to its circular orbit, while the angular acceleration of the rod at that instant is 4.50 rad/s^2. What is the magnitude of the sphere's translational acceleration at that instant?

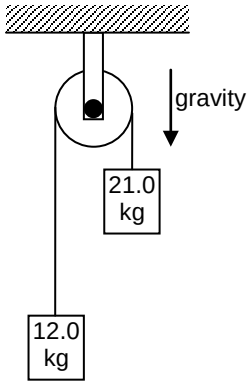


a. 13.7 m/s^2 b. 5.40 m/s^2 c. 12.9 m/s^2 d. 7.50 m/s^2 e. 9.24 m/s^2

26. A grindstone undergoing constant angular acceleration increases in angular speed from 4.20 rad/s to 13.20 rad/s in a time of 3.00 s. Through what angle does the grindstone turn during this time interval?

a. 40.5 rad b. 39.6 rad c. 26.1 rad d. 13.5 rad e. 54.0 rad

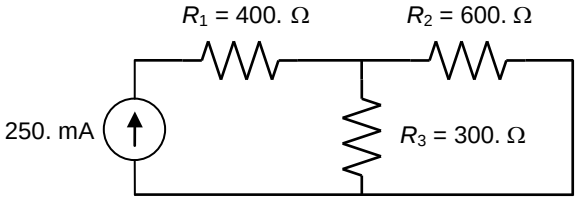
27. An Atwood machine consists of a 12.0 kg block attached to a 21.0 kg block via a light inextensible cord which is hung over a pulley attached to the ceiling. The pulley has a radius of 15.0 cm, a moment of inertia of 1.74 $kg \cdot m^2$ and a frictional torque in its axle equal to 2.40 $N \cdot m$. If the system starts from rest, what is the angular speed of the pulley after it has rotated through 2.00 revolutions? Assume that the cord does not slip on the pulley, and the blocks do not encounter any obstructions.



a. 11.6 rad/s
b. 10.5 rad/s
c. 19.1 rad/s
d. 21.2 rad/s
e. 12.5 rad/s

28. What is the magnitude of the voltage across the 250. mA current source shown in the diagram?

a. 100. V
b. 150. V
c. 175 V
d. 325 V
e. 0.00 V



29. A standing wave pattern on a 2.50 m long string is given by

$$y = 0.050 \text{ meter } \sin\left(\frac{2\pi \text{ rad}}{\text{meter}} x\right)\cos\left(\frac{250\pi \text{ rad}}{\text{second}} t\right)$$

where *y* is the transverse displacement of the string at position x, and t represents time. How many lobes are represented by this standing wave pattern?

a. 50 b. 125 c. 3 d. 4 e. 5

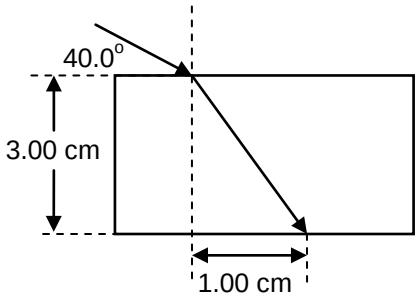
30. The density of mercury at 0.00 ^oC is 13.6 kg/m^3. Mercury's coefficient of **linear** expansion is 6.07x 10^{-5}/ ^oC. Assuming that the coefficient of linear expansion remains constant, what is the density of mercury at 190.00 ^oC?

a. 13.8 kg/m^3 b. 13.4 kg/m^3 c. 13.1 kg/m^3 d. 14.1 kg/m^3 e. 13.3 kg/m^3

31. The specific heat of water at 15.0 ^oC is 4186 J/(kg ^oC). If a 0.750 A current flows for 2.00 minutes through a 440. Ω resistor which is immersed in 385 grams of water initially at 15.0^oC, how much will the temperature of the water **change**, assuming that all of the heat goes to the water?

a. 33.4 ^oC b. 0.0246 ^oC c. 0.307 ^oC d. 18.4 ^oC e. 24.6 ^oC

32. A ray of light travels from air into a transparent block along the path shown in the diagram. What is the index of refraction of the substance making up the block?



a. 2.42
b. 2.03
c. 2.30
d. 1.93
e. 1.48

33. A spherical mirror has a focal length of +12.0 cm. If a 2.50 cm tall object is placed 35.0 cm in front of the mirror, what is the image height?

a. 0.522 cm (inverted)
b. 18.3 cm (erect)
c. 0.638 cm (erect)
d. 1.30 cm (inverted)
e. 0.255 cm (erect)

34. A helium-neon laser beam (frequency equal to 4.738×10^{14} Hz) is incident normally on a diffraction grating, producing a first order maximum at 25.7^{o}. What is the spacing between adjacent slits in the grating?

a. 0.702 μm b. 1.31μm c. 4.87 fm d. 0.915 fm e. 1.46 μm

35. A proton moves with a speed of 0.925c, where c is the speed of light. What is the kinetic energy of the proton (considering relativistic effects)?

a. 0.396 nJ b. 0.169 nJ c. 64.3 pJ d. 0.245 nJ e. 0.150 nJ