Worldwide Youth in Science and Engineering

2013 Academic Challenge

PHYSICS TEST - STATE

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 incorrect answers.

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 (State) – 2013

1. An automobile traveling along a straight road with an initial speed 15.0 m/s accelerates uniformly to a speed 25.0 m/s over a time interval of 10.0 s. What is the magnitude of the automobile's acceleration during this time interval?

   a. 1.00 m/s^2 b. 1.50 m/s^2 c. 2.50 m/s^2 d. 3.50 m/s^2 e. 4.00 m/s^2

2. In problem 1, how far did the automobile travel during the 10.0 s time interval?

   a. 175. m b. 200. m c. 225. m d. 250. m e. 400. m

3. In martian units, the speed of light is 5.00×10^4 thhrips/gloob. If a martian measures one earth day (24.0 hours) to be 6.00×10^8 gloobs, what is the length of 1.00 thhrips?

   a. 0.863 m
   b. 20.7 m
   c. 1.67×10^3 m
   d. 8.33×10^5 m
   e. 3.00×10^{13} m

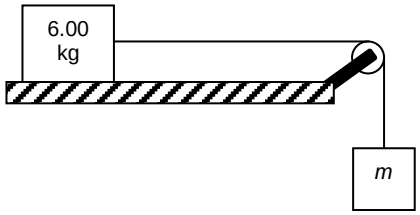
4. A person runs 100. m north in 15.0 s, turns and runs 400. m east in 80.0 s, and turns again and runs 400. m south in 90.0 s. What is the magnitude of the total displacement of the person over the entire run?

   a. 100. m
   b. 500. m
   c. 600. m
   d. 700. m
   e. 900. m

5. In problem 4, what is the average speed of the person over the entire run?

   a. 2.70 m/s b. 4.86 m/s c. 5.37 m/s d. 16.1 m/s e. 333. m/s

6. A 6.00 kg block on a level, frictionless surface is attached by a rope to a second block with mass *m* that is freely suspended from the end of the rope, as shown in the diagram. The pulley is frictionless, and the mass of the rope is negligible. If the tension in the rope is 30.0 N, what is the mass *m*?



   a. 0. 249 kg b. 1.57 kg c. 2.03 kg d. 3.06 kg e. 6.25 kg

7. A pilot flies a plane 200. miles in a direction 30.0° north of east to reach an intermediate destination. Then the pilot flies the plane 400. miles in a direction 10.0° south of east to the final destination. What is the distance of the final destination from the starting point?

   a. 257. miles b. 278. miles c. 488. miles d. 568. miles e. 600. miles

8. A mechanical system results in a force of magnitude F that depends on displacement x as $F = bx^3$, where b is a known constant. What are the correct SI units of b?

   a. $kg \cdot m^2/s^2$ b. $kg \cdot m^4/s^2$ c. $kg/(m^3 \cdot s^2)$ d. $kg/(m \cdot s^2)$ e. $kg/(m^2 \cdot s^2)$

9. A constant 40.0 N force acts toward the north on a 5.00 kg object, and a constant 30.0 N force acts toward the east on the same object. What is the total work done on the object by these two forces as the object undergoes a displacement of 10.0 m in a direction 30.0° South of East?

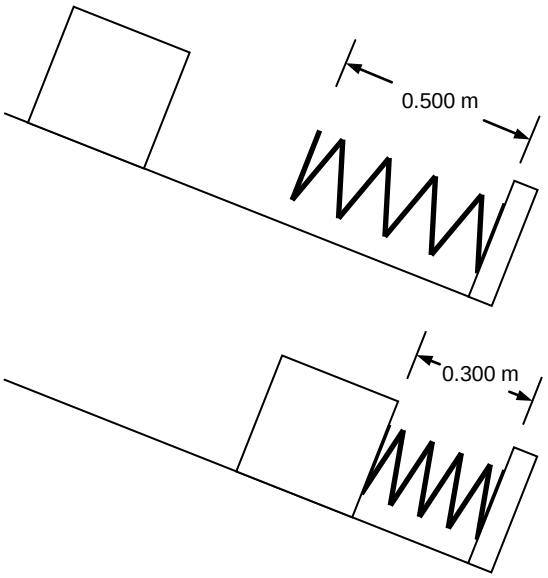
   a. 59.8 J b. 333. J c. 460. J d. 496. J e. 700. J

10. Only conservative forces act on an object as it moves from point A to point B along an arbitrary path. How does the change in kinetic energy of the object depend on the path followed to get from point A to point B?

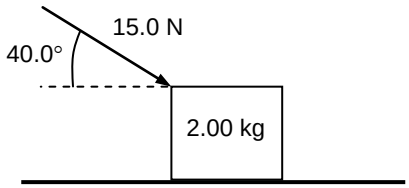
   a. The change in kinetic energy is proportional to the path length.
   b. The change in kinetic energy is proportional to the path length squared.
   c. The change in kinetic energy is proportional to the square root of the path length.
   d. The change in kinetic energy is dependent on both the path length and direction.
   e. The change in kinetic energy is independent of the path.

11. A 5.00 kg block is released from rest from the position shown in the upper diagram. The block slides down the frictionless surface and contacts the initially relaxed spring. The block comes to rest in the position shown in the lower diagram. If the spring constant of the spring is 400. N/m, what is the change in gravitational potential energy as the block slides down the slope?

   a. −32.0 J
   b. −8.00 J
   c. 8.00 J
   d. 16.0 J
   e. 32.0 J



12. As shown in the diagram, a 2.00 kg block is acted on by a 15.0 N force acting in a direction 40.0° below the horizontal as it slides toward the right on a horizontal surface. The magnitude of the kinetic friction force acting on the block is 8.00 N. What is the magnitude of the acceleration of the block?



a. 0.821 m/s^2 b. 1.75 m/s^2 c. 3.50 m/s^2 d. 5.75 m/s^2 e. 7.50 m/s^2

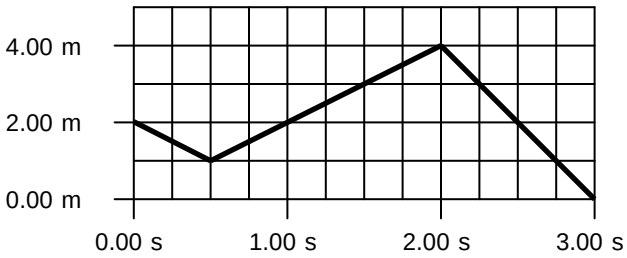
13. In problem 12, what is the coefficient of kinetic friction between the block and the horizontal surface?

a. 0.274 b. 0.408 c. 0.696 d. 0.755 e. 0.830

14. A 7.00 kg object is acted on by a force for 2.00 s. The object's momentum changes from 800. kg·m/s west to 200. kg·m/s east during the 2.00 s interval. What was the magnitude of the average force that acted on the object during the 2.00 s interval?

a. 71.4 N b. 134. N c. 300. N d. 500. N e. 621. N

15. A graph of position as a function of time is shown for the rectilinear motion of an object. What is the average velocity of the object between time 0.00 s and time 3.00 s?



a. −4.00 m/s
b. −2.00 m/s
c. −0.67 m/s
d. 0.00 m/s
e. 4.00 m/s

16. In problem 15, what is the average speed of the object between time 0.0 s and time 3.00 s?

a. 0.67 m/s b. 1.33 m/s c. 2.67 m/s d. 3.00 m/s e. 4.00 m/s

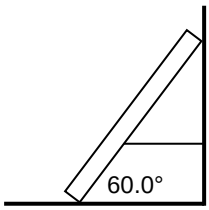
17. The total angular momentum of a system is a conserved quantity only if

a. no net external force acts on the system.
b. no net external torque about any axis acts on the system.
c. no internal forces act within the system.
d. no internal torques act within the system.
e. no internal forces or internal torques act within the system.

18. A 1.00 kg puck sliding along a frictionless surface at 5.00 m/s strikes a second puck that is initially stationary. After the collision, the first puck continues to move in the same direction as before the collision, but at a speed of 1.00 m/s. If the collision is perfectly elastic, what is the mass of the second puck?

a. 0.667 kg b. 1.33 kg c. 1.50 kg d. 2.00 kg e. 4.00 kg

19. A 4.00 kg uniform plank of length *L* leans against a wall such that the plank makes a 60.0° angle with the floor. Both the wall and the floor are frictionless. A horizontal rope of negligible mass, tied to the wall, holds the plank in place. The rope is attached to the plank at a distance *L* / 3.00 from the lower end of the plank. What is the tension in the rope?



a. 17.0 N b. 20.0 N c. 19.6 N d. 25.2 N e. 41.2 N

20. A planet is discovered orbiting a distant star at a distance of 8.00×10^{8} km from the star. The period of the planet's orbit is 30.0 years. Assuming the planet's mass is much less than that of the star, what is the mass of the star?

a. 6.78×10^{19} kg
b. 3.38×10^{29} kg
c. 2.78×10^{36} kg
d. 3.95×10^{37} kg
e. 3.95×10^{38} kg

21. In problem 20, if the orbit of the planet is circular, what is the acceleration of the planet?

a. 3.52×10^{-5} m/s^2
b. 6.42×10^{-7} m/s^2
c. 2.78×10^{-3} m/s^2
d. 3.95×10^{-2} m/s^2
e. 9.8 m/s^2

22. A heat engine has 2000. J of heat added at a temperature of 1200. °C during each cycle. If it exhausts waste heat at 400. °C, what is the minimum possible amount of heat it must exhaust during each cycle?

a. zero b. 378. J c. 667. J d. 800. J e. 914. J

23. An 8.00 kg sample of a liquid at temperature 20.0 °C is added to a 4.00 kg sample of the same liquid at –20.0 °C. During the process of reaching equilibrium at 15.0 °C, 40.0 Cal of heat are added to the mixture. What is the specific heat of the liquid?

a. 0.200 Cal/(kg·C°)
b. 0.400 Cal/(kg·C°)
c. 0.600 Cal/(kg·C°)
d. 0.800 Cal/(kg·C°)
e. 1.00 Cal/(kg·C°)

24. An electric charge Q moves from point A to point B which are a distance *d* apart. The change in electrostatic potential energy is the product of the charge Q and

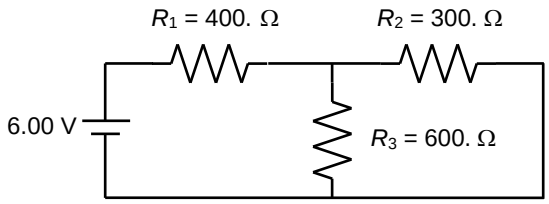
a. electric field at point A subtracted from the electric field at point B.
b. charge at point A subtracted from the charge at point B.
c. charge at point A subtracted from the charge at point B, and the result divided by *d*.
d. charge at point A subtracted from the charge at point B, and the result divided by d^2.
e. electric potential at point A subtracted from the electric potential at point B.

25. Applying Faraday's Law, which situation results in zero induced EMF in a planar loop of wire with non-zero area *A*?

a. The loop is rotating about an axis perpendicular to a non-zero, uniform, constant magnetic field, while the centroid of the loop remains stationary.
b. The loop is traveling through a non-zero, uniform, constant magnetic field without changing its orientation.
c. The loop has an area decreasing with time, and its plane is perpendicular to the area of a non-zero, uniform, constant magnetic field, while the loop does not move.
d. The magnetic flux through the loop is increasing.
e. The magnetic flux through the loop is decreasing.

26. What is the voltage across the 600. Ω resistor in the circuit shown in the diagram?

a. 2.00 V
b. 2.67 V
c. 3.60 V
d. 4.15 V
e. 6.00 V



27. Two objects float in the same liquid. Object A floats with 60% of its volume above the surface of the liquid and object B floats with 20% of its volume above the surface of the liquid. If the mean density of object A is 200. kg/m^3, what is the mean density of object B?

a. 100. kg/m^3 b. 200. kg/m3 c. 300. kg/m^3 d. 400. kg/m^3 e. 600. kg/m^3

28. A string of length 4.00 m is tied between two rigid anchor points. The lowest natural frequency of vibration of the string is 50.0 Hz. What is the speed of waves that travel on the string?

a. 100. m/s b. 200. m/s c. 250. m/s d. 300. m/s e. 400. m/s

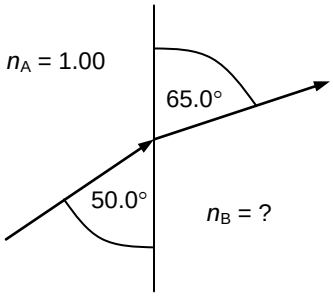
29. A lens forms a virtual image of a real object. The image is 30.0 cm from the lens and its linear magnification is 4.00. What is the focal length of the lens?

a. 6.00 cm b. 7.50 cm c. 10.0 cm d. 37.5 cm e. 120. cm

30. A particle with rest mass m_0 moves with speed 0.800c. What is the kinetic energy of the particle?

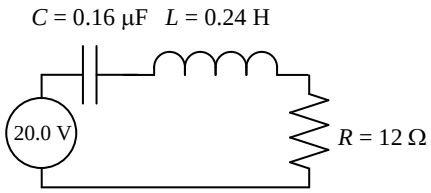
a. 0.600 m_0c^2
b. 0.667 m_0c^2
c. 0.800 m_0c^2
d. 1.250 m_0c^2
e. 1.667 m_0c^2

31. Light encounters the vertical interface between two materials from the left and exits to the right, as shown. The refractive index of the material to the left of the interface is 1.00. What is the refractive index of the material to the right of the interface?



a. 1.18
b. 1.26
c. 1.37
d. 1.41
e. 1.52

32. An RLC series circuit is powered by a 20.0 V rms AC source, as shown. What is the rms current that flows in the circuit if the frequency of the source is 4.00 kHz?

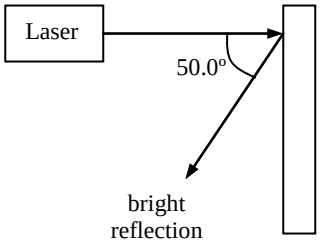


a. 22.2 μA
b. 3.46 mA
c. 33.1 mA
d. 1.63 A
e. 22.2 A

33. In problem 32, for what source frequency does the rms current reach a maximum?

a. 38.6 Hz
b. 812. Hz
c. 1.67 kHz
d. 5.13 kHz
e. 12.6 kHz

34. A finely machined surface has a large number of identical uniformly-spaced parallel grooves. When a laser that emits radiation of wavelength 543. nm illuminates the surface in a direction perpendicular to the surface, a bright reflection occurs in a direction 50.0º away from the perpendicular to the surface. What is the minimum spacing of the grooves on the machined surface?



a. 416. nm
b. 543. nm
c. 709. nm
d. 948 nm
e. 1086 nm

35. Which of the following particles is a lepton?

a. proton b. neutron c. electron d. pion e. strange quark