Worldwide Youth in Science and Engineering

2012 Academic Challenge

PHYSICS TEST - STATE FINAL

This Test Consists of 35 Questions

Physics Test Production Team
Len Storm, Eastern Illinois University – Author/Team Leader
Doug Brandt, Eastern Illinois University – Author
Kevin Pitts, University of Illinois at Urbana-Champaign – Reviewer
Mary Weaver, WYSE – Coordinator of Test Production

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 (State Final) – 2012

1. How many Newtons are equal to 1.00 gram·millimeter/minute^2?

   a. 2.78×10^{-10}
   b. 3.60×10^{-3}
   c. $3.60 \times 10^{+3}$
   d. $3.60 \times 10^{+9}$
   e. 1.67×10^{-8}

2. A car starts from rest and accelerates with constant acceleration to a speed of 20.0 m/s in 5.00 s. What is the magnitude of the car's acceleration?

   a. 2.00 m/s^2 b. 4.00 m/s^2 c. 8.00 m/s^2 d. 50.0 m/s^2 e. 100. m/s^2

3. In the situation described in problem 2, how far has the car traveled in the 5.00 s during which the car accelerated?

   a. 20.0 m b. 100. m c. 40.0 m d. 50.0 m e. 25.0 m

4. For motion that occurs during a specified interval of time, which of the following is always true?

   a. The average speed is greater than the magnitude of the average velocity.
   b. The average speed is greater than or equal to the magnitude of the average velocity.
   c. The average speed is equal to the magnitude of the average velocity.
   d. The average speed is less than the magnitude of the average velocity.
   e. The average speed is less than or equal to the magnitude of the average velocity.

5. A ball rolls off a table with an initial horizontal velocity and strikes the floor after falling 0.800 m. How much time does it take the ball to fall the 0.800 m?

   a. 0.0816 s b. 0.115 s c. 0.404 s d. 0.724 s e. 1.63 s

6. In problem 5, the velocity of the ball is in a direction 80.0° below horizontal just before the ball strikes the floor. What was the horizontal speed of the ball when it left the table?

   a. 0.698 m/s b. 1.20 m/s c. 1.67 m/s d. 3.96 m/s e. 22.5 m/s

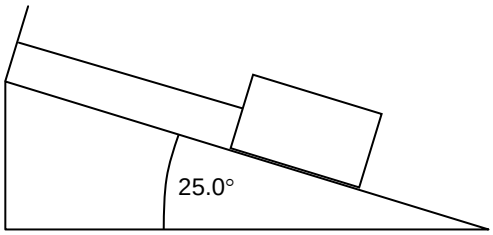
7. A 60.0 kg skydiver opens her parachute and a moment later her acceleration is 4.00 m/s^2 upward. What is the total upward component of force of the parachute shroud lines on the skydiver at that moment?

   a. 1.50 N b. 24.0 N c. 240. N d. 348. N e. 828. N

8. A 40.0 kg block is dragged across a horizontal surface by a 70.0 N force at an angle 30.0° above horizontal. If the block is moving at constant velocity, what is the coefficient of kinetic friction between the block and the horizontal surface?

   a. 0.0893 b. 0.155 c. 0.170 d. 0.179 e. 0.875

9. A block is held in place on a frictionless 25.0° inclined plane by a string that will break if the tension in the string exceeds 200. N. What is the maximum mass of the block such that the string will not break?



a. 22.5 kg
b. 48.3 kg
c. 184. kg
d. 221. kg
e. 473. kg

10. A 3.00 kg mass is attached to a spring. The mass undergoes simple harmonic motion with a period of 2.00 s. What is the spring constant of the spring?

a. 0.667 N/m b. 1.50 N/m c. 4.19 N/m d. 9.42 N/m e. 29.6 N/m

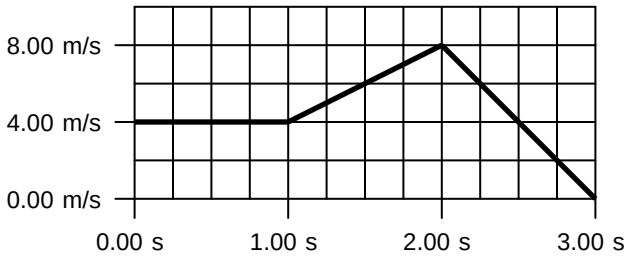
11. A figure skater begins a spin with an angular speed 4.00 rad/s while the configuration of the skater's body has a moment of inertia 30.0 $kg \cdot m^2$ about the vertical rotation axis. The skater increases the angular speed of rotation to 6.00 rad/s by a body reconfiguration which changes the skater's moment of inertia. If no external torque acts on the skater, how much work did the skater do to reconfigure her body?

a. 120. J b. 240. J c. 300. J d. 360. J e. 600. J

12. A disk is rotating about a fixed axis through the center of the disk perpendicular to the plane of the disk. If the disk has constant angular velocity 2.00 revolutions per second, what is the magnitude of the acceleration of a point on the disk located 4.00 cm from the axis of rotation?

a. zero b. 0.160 m/s^2 c. 1.01 m/s^2 d. 6.32 m/s^2 e. 16.0 m/s^2

13. A graph of velocity as a function of time is shown for the rectilinear motion of an object. What is the magnitude of the displacement of the object during the 3.00 s interval shown in the graph?



a. 9.00 m
b. 12.0 m
c. 13.0 m
d. 14.0 m
e. 20.0 m

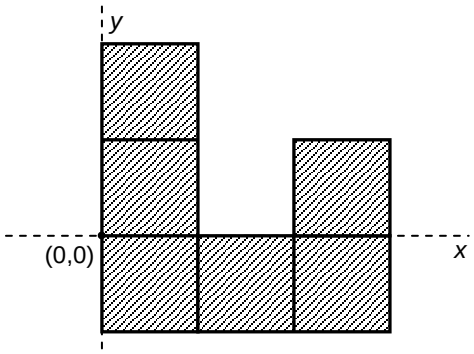
14. A planet is discovered orbiting a distant star at a distance of 8.00×10^8 km from the star. The period of the planet's orbit is 30.0 years. Assuming the planet's mass is much less than that of the star, what is the mass of the star?

a. 6.78×10^{39} 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

15. A straight wire with a circular cross-section has an initial volume 3.00×10^{-6} m^3 and an initial length 2.00000 m. If the wire stretches to a length 2.00050 m when a 40.0 N tension is applied, what is Young's modulus for the material from which the wire is made?

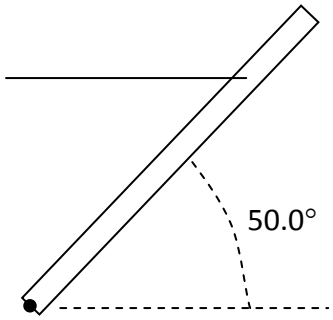
    a. 3.33×10^{7} N/m^2
    b. 6.67×10^{7} N/m^2
    c. 1.33×10^{8} N/m^2
    d. 5.33×10^{10} N/m^2
    e. 1.07×10^{11} N/m^2

16. A thin plate of material of uniform density is shown in the diagram. Each square indicated on the plate is 1.00 m by 1.00 m. What is the location of the center of mass of the plate?



    a. x = 0.889 m, y = 0.111 m
    b. x = 1.33 m, y = 0.167 m
    c. x = 0.404 m, y = –0.111 m
    d. x = 0.555 m, y = 0.322 m
    e. x = 1.67 m, y = 1.08 m

17. A uniform density board has weight 100. N and length 2.00 m. It is pinned at its lower left end and a horizontal string tied 0.500 m from the upper end of the board prevents the board from falling from the position shown. What is the tension in the string?



    a. 50.0 N
    b. 55.9 N
    c. 66.7 N
    d. 79.5 N
    e. 133. N

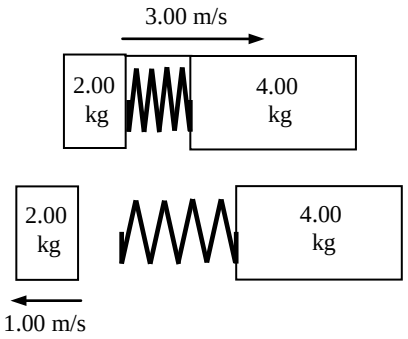
18. A projectile is fired at an angle of 50.0° above horizontal with an initial speed of 40.0 m/s from a height of 30.0 m above the level ground. Assume that the drag force on the projectile is negligible. How much time passes before the projectile reaches the ground?

    a. 2.11 s b. 5.88 s c. 6.37 s d. 7.11 s e. 8.27 s

19. A conservative system's total kinetic energy increases 200. J while no work is done on the system by external forces. Which statement is true about the system during this interval?

    a. A non-conservative force within the system did –200. J of work.
    b. A non-conservative force within the system did +200. J of work.
    c. The potential energy of the system decreased by 200. J.
    d. The potential energy of the system increased by 200. J.
    e. This situation is impossible, as energy is not conserved.

20. A 4.00 kg mass is attached to a 2.00 kg mass. Between the two masses is a compressed spring with negligible mass. The combined object has a velocity 3.00 m/s east as it slides on a level, frictionless surface. When the connection between the objects is broken, the spring pushes the objects apart, and the 2.00 kg mass ends up with a velocity 1.00 m/s west. What is the final velocity of the 4.00 kg mass?

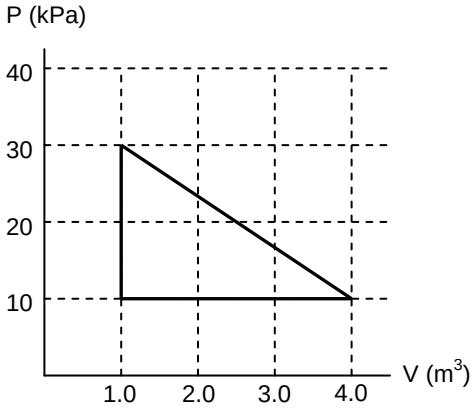


a. 3.00 m/s
b. 4.00 m/s east
c. 4.00 m/s west
d. 4.50 m/s east
e. 5.00 m/s east

21. A 4.00 kg object has a moment of inertia 2.00 kg·m^2 about an axis displaced 0.400 m from the center of mass of the object. What is the moment of inertia about an axis parallel to the first but displaced 0.300 m from the center of mass?

a. 2.36 kg·m^2 b. 2.04 kg·m^2 c. 1.96 kg·m^2 d. 1.72 kg·m^2 e. 1.60 kg·m^2

22. The P-V diagram for a process on a closed system is shown. If the process proceeds clockwise around the P-V trajectory, what is the net work done <u>on</u> the system during one complete cycle of the process?

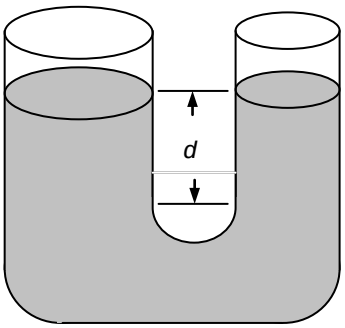


a. zero
b. 30. kJ
c. –30. kJ
d. 60. kJ
e. –60. kJ

23. A fixed amount of ideal gas is compressed isothermally from a volume 3.00 m^3 to a volume 1.00 m^3. If the gas had an initial absolute pressure *P*, what is the final absolute pressure of the gas after compression?

a. (3.00)*P* b. *P*/(3.00) c. *P* d. (2.00)*P* e. (–2.00)*P*

24. A static, Newtonian fluid with density 1200. kg/m^3 partially fills the structure as shown in the figure. The vertical tube on the left has a circular cross-section of diameter 20.0 cm and the vertical tube on the right has a circular cross-section of diameter 10.0 cm. If the pressure at depth *d* below the surface in the right vertical tube is 200. kPa, what is the pressure at depth *d* in the left vertical tube?



a. 200. kPa b. 800. kPa c. 50.0 kPa d. 400. kPa e. 100. kPa

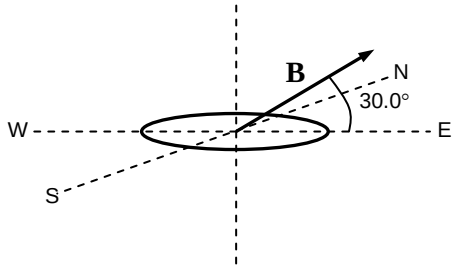
25. Starting with two equal positive charges separated by an infinite distance, it takes work *W* to bring them to a distance *d* from each other. How much additional work is required to bring them to a distance *d*/2 from each other once they are a distance *d* apart?

a. *W*/4 b. *W*/2 c. *W* d. 2*W* e. 3*W*

26. A negative charge moves toward the east in a magnetic field directed vertically upward. What is the direction of the magnetic force on the charge?

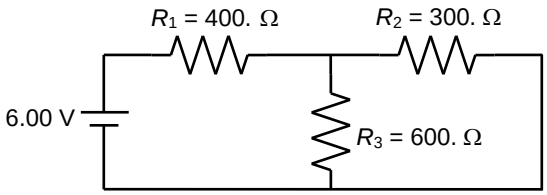
a. north b. south c. west d. down e. 45.0° south of west

27. A circular loop of wire of radius 30.0 cm with resistance 2.00 Ω lies in a horizontal plane. The loop is in a uniform 6.00 T magnetic field in a direction toward the east and 30.0° above horizontal. The magnetic field decreases in magnitude at a constant rate to 2.00 T in 8.00 ms. What is the induced electromotive force in the loop during this 8.00 ms time interval?



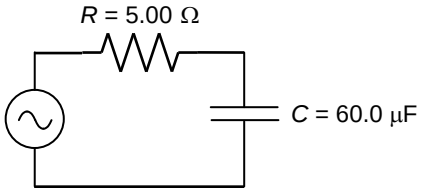
a. 33.6 V b. 59.1 V c. 70.7 V d. 88.8 V e. 95.0 V

28. What is the electrical power into the 300. Ω resistor in the circuit shown in the diagram?



a. 108. mW
b. 80.0 mW
c. 37.7 mW
d. 22.0 mW
e. 13.3 mW

29. A 5.00 Ω resistor and a 60.0 μF capacitor are connected in series to a sinusoidal voltage source with an angular frequency 800. s^{-1}. If the amplitude of the current in the circuit is 50.0 mA, what is the amplitude of the voltage source?



a. 1.07 V b. 3.33 V c. 3.67 V d. 5.20 V e. 120. V

30. A source of light is located 20.0 cm from the surface of a mirror. The mirror forms a virtual image of the source at a distance 30.0 cm from the mirror. What is the focal length of the mirror?

a. 60.0 cm b. 12.0 cm c. 20.0 cm d. –12.0 cm e. –15.0 cm

31. In the situation described in problem 30, what is the linear magnification of the image?

a. –1.50 b. +1.50 c. –0.667 d. +0.667 e. –0.333

32. Mary measures the length of a spaceship passing by at a speed of 0.900*c* to be 200. m along its direction of travel. What does Bill, riding on the spaceship, measure the length of the spaceship to be?

    a. 87.2 m b. 120. m c. 200. m d. 240. m e. 459 m

33. What is the photon energy of electromagnetic waves that have a period of 10.0 s?

    a. 1.62×10^{-20} J
    b. 1.99×10^{-24} J
    c. 1.99×10^{-26} J
    d. 6.63×10^{-33} J
    e. 6.63×10^{-35}J

34. A sample of a radioactive isotope with a half-life 4.00 hours initially contains 1.00×10^{18} atoms of the isotope. How many atoms of the isotope are in the sample after 2.00 hours has elapsed?

    a. 0.750×10^{18}
    b. 0.250×10^{18}
    c. 0.500×10^{18}
    d. 0.707×10^{18}
    e. 0.693×10^{18}

35. During an alpha decay process in which the nucleus emits an He_2^4 nucleus, the original nucleus

    a. decreases in atomic mass number by two.
    b. increases in atomic mass number by two.
    c. decreases in atomic number by four.
    d. increases in atomic number by two.
    e. decreases in atomic number by two.