2015 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 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)
Electrostatic Constant	$k=(4\pi\varepsilon_0)^{-1}$	8.988×10^{9} N·m^2/C^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

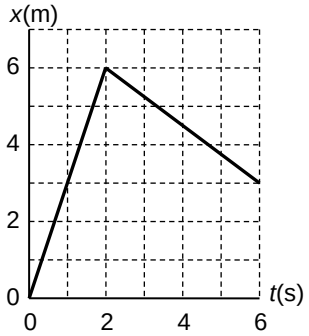
0.00 ^{o}C = 273.15 K

WYSE – Academic Challenge
Physics Test (State) – 2015

1. Given M = mass, L= length, and T = time, the dimensions of angular momentum are

a. $\frac{M \cdot L^2}{T}$. b. $\frac{M \cdot L}{T^2}$. c. $\frac{M \cdot L^2}{T^2}$. d. $\frac{M^2 \cdot L^2}{T}$. e. $\frac{M^2 \cdot L^2}{T}$.

2. The graph shows the position versus time plot of the motion of an object which is moving along the x-axis. What is the average speed of the object between 0.0 s and 2.0 s?



a. 0.50 m/s
b. 0.60 m/s
c. 1.15 m/s
d. 1.5 m/s
e. 3.00 m/s

3. In the previous problem, what is the average speed of the object between 0.0 s and 6.0 s?

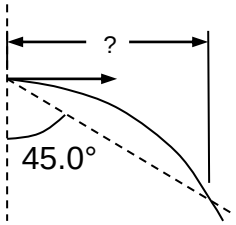
a. 0.50 m/s b. 0.60 m/s c. 1.1 m/s d. 1.5 m/s e. 1.9 m/s

4. An object is dropped from rest. 2.00 s later, it has fallen to a position which is 40.0 m above the ground. How much time does it take to reach the ground from the time it was dropped?

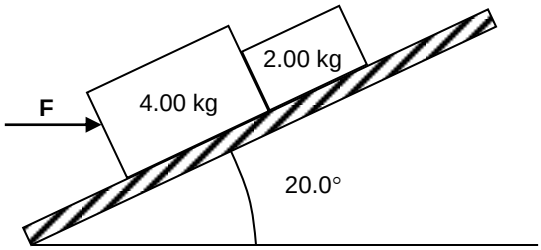
a. 5.22 s b. 4.87 s c. 4.33 s d. 3.49 s e. 3.23 s

5. An object is thrown horizontally at a speed 20.0 m/s. How far horizontally has it travelled when it is located along a line directed 45° below horizontal from the point of release?

a. 9.8 m
b. 19.6 m
c. 47.8 m
d. 63.3 m
e. 81.6 m



6. A 4.00 kg block and a 2.00 kg block on a frictionless surface which is inclined 20.0° to the horizontal are in contact with each other. A horizontal force **F** pushes the blocks up the incline with an acceleration 2.00 m/s^2. What is the magnitude of force **F**?



a. 11.3 N b. 12.0 N c. 12.8 N d. 32.1 N e. 34.2 N

7. In the situation described in problem 6, what is the magnitude of the force of contact between the two blocks if force **F** just holds the blocks in place?

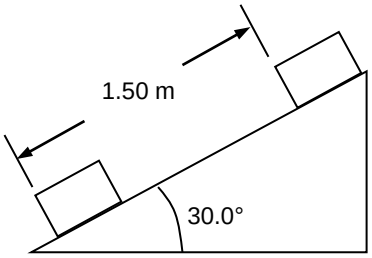
a. 0.00 N b. 6.70 N c. 18.4 N d. 19.6 N e. 20.1 N

8. A 20.0 kg block is dragged across a horizontal surface by a 60.0 N force at an angle 20.0° 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. 0.198 b. 0.244 c. 0.321 d. 0.400 e. 0.433

9. A 2.00 kg block is sliding down an incline, as shown in the diagram to the right. At the upper position it has a speed 2.00 m/s. When it reaches the lower position, its speed is 4.00 m/s. What is the coefficient of kinetic friction between the block and the incline?

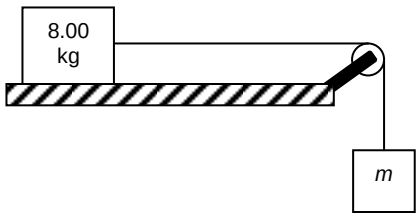
a. 0.106
b. 0.116
c. 0.232
d. 0.333
e. 0.500



10. A 3.00 kg object is acted on by two forces, $\mathbf{F}_A$ and $\mathbf{F}_B$. Force $\mathbf{F}_A$ has a magnitude 2.00 N and is in a direction 50.0° east of north, Force $\mathbf{F}_B$ has a magnitude 4.00 N and is in a direction 20.0° north of west. Determine the magnitude of the acceleration of the 3.00 kg object.

a. 0.619 m/s^2 b. 0.883 m/s^2 c. 1.15 m/s^2 d. 3.44 m/s^2 e. 4.24 m/s^2

11. An 8.00 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 40.0 N, what is the mass *m*?



a. 2.89 kg b. 6.77 kg c. 8.33 kg d. 13.2 kg e. 18.9 kg

12. Is knowing the initial position and the constant acceleration of an object sufficient information to determine the position of the object at later times?

    a. Yes.
    b. No, the mass of the object must also be known.
    c. No, the initial velocity of the object must also be known.
    d. No, all the forces acting on the object must be known.
    e. No, mass, initial position, and all forces must be known.

13. At a given instant, a wheel is rotating about a stationary axis through its center at 2.00 rad/s, and it has an angular acceleration of 3.00 rad/s^2. What is the magnitude of the acceleration of a point on the wheel located 0.200 m from the axis?

    a. 0.600 m/s^2 b. 0.700 m/s^2 c. 0.800 m/s^2 d. 1.00 m/s^2 e. 9.80 m/s^2

14. An object begins at point A traveling at speed *v* while acted on by a single force **F**. The object follows a path through space and returns to point A, but has a speed 2*v* when it returns. Which of the following conclusions can be reached about the force **F** acting on the object as it followed its path?

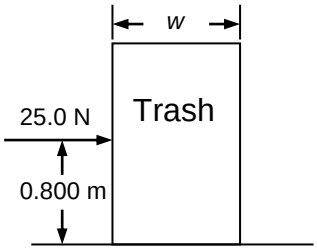
    a. Force **F** is a gravitational force.
    b. Force **F** always acts in a direction opposite to the velocity of the object.
    c. Force **F** always acts in a direction perpendicular to the velocity of the object.
    d. Force **F** is a nonliberal force.
    e. Force **F** is a nonconservative force.

15. A 500. kg boat has an initial speed of 8.00 m/s as it passes under a bridge. At that instant an 80.0 kg man jumps vertically downward into the boat from the bridge. What is the speed of the boat after the boat and man have come to a common speed, assuming that drag between the water and the boat is negligible?

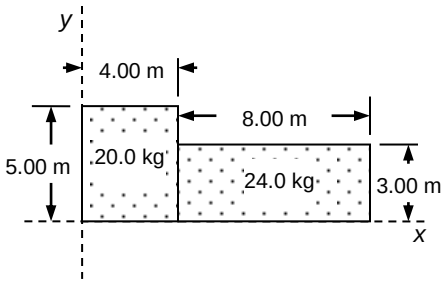
    a. 6.33 m/s b. 6.90 m/s c. 7.20 m/s d. 7.33 m/s e. 7.50 m/s

16. An empty trash can, assumed to be a hollow, enclosed cylinder made from sheeting with uniform thickness and density, has a mass 6.00 kg and a height 1.600 m. A horizontal force acting on the side of the trash can at a distance one half the height of the trash can, 0.800 m above the ground, will tip the trash can if it has a minimum magnitude 25.0 N. What is the width, *w*, of the trash can?

    a. 0.566 m
    b. 0.592 m
    c. 0.680 m
    d. 0.701 m
    e. 0.724 m



17. A 5.00 m by 4.00 m uniform, thin, rectangular plate with a mass 20.0 kg and a 3.00 m by 8.00 m uniform, thin, rectangular plate with a mass 24.0 kg are arranged as shown. What is the location of the center of mass of this system?



a. x = 5.27 m, y = 1.95 m
b. x = 6.11m, y = 1.84 m
c. x = 5.39 m, y = 1.98 m
d. x = 5.68 m, y = 2.11 m
e. x = 5.42 m, y = 1.88 m

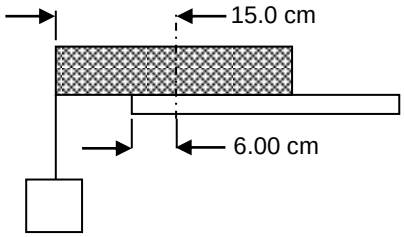
18. For the arrangement of masses specified in problem 17, what is the total moment of inertia of this system about the z axis? (The z-axis passes through the origin of the xy coordinate system in a direction perpendicular to the xy plane.) Recall that the moment of inertia of a rectangular plate about an axis through its center and perpendicular to the plate is given by $I_{zc} = \frac{1}{12} m\left(a^2 + b^2\right)$, where a and b are the lengths of the sides of the rectangle, and m is the mass of the rectangle.

a. 214 kg·m^2
b. 614 kg·m^2
c. 954 kg·m^2
d. 1.80×10^3 kg·m^2
e. 2.01×10^3 kg·m^2

19. A figure skater is spinning with a rotation rate 1.00 rev/s when she has a moment of inertia 3.00 kg·m^2. She moves her arms to a position so that her rate of rotation becomes 2.5 rev/s. How much work was done by the skater to increase the rate of rotation?

a. 88.8 J b. 68.2 J c. 53.7 J d. 48.9 J e. 14.1 J

20. A 4.00 kg uniform block of length 30.0 cm rests on the edge of a table such that its center is 6.00 cm from the edge of the table. A second block is suspended from the end of the first block, as shown. What is the greatest mass for the suspended block which will not cause the first block to tip and fall off of the table?

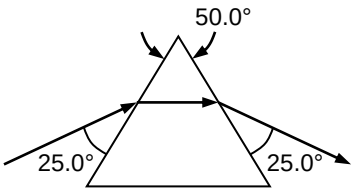


a. 2.67 kg b. 2.98 kg c. 3.22 kg d. 3.55 kg e. 6.00 kg

21. A 100. kg running back is carrying the football and running south at 6.00 m/s. An 80.0 kg linebacker is running north at 7.00 m/s when she tackles the running back head on and both players come to an immediate rest. If the tackling process took 0.400 s, what was the magnitude of the average horizontal component of force applied to the ground by both players during the tackle?

a. 100. N south b. 200. N north c. 200. N south d. 300. N north e. 400 N. south

22. A ray of light follows the symmetric path shown through a prism with a 50.0° apex angle. The refractive index exterior to the prism is 1.000. What is the refractive index of the prism?



a. 1.33
b. 1.47
c. 1.52
d. 1.88
e. 2.14

23. 4.00 moles of a monatomic ideal gas are at a temperature 200.°C and an absolute pressure 1.00 atmosphere. If the volume of the gas remains constant, what will be the absolute pressure of the gas if the temperature increases to 400.°C?

a. 0.500 atmospheres
b. 1.00 atmospheres
c. 1.42 atmospheres
d. 2.00 atmospheres
e. 2.73 atmospheres

24. In the situation described in problem 23, what is the change in internal energy of the gas during the increase in pressure?

a. 3.87 kJ b. 6.65 kJ c. 7.45 kJ d. 8.66 kJ e. 9.98 kJ

25. A mixture of 20.0 g of ice at -5.00 °C and 100.0 g of water at 0.00 °C is warmed until the ice completely melts and the system is at a uniform 20.00 °C. How much heat was added to the system? L_{fusion} = 334 J/g, C_{ice} = 2.11 J/(g·C°), C_{water} = 4.18 J/(g·C°).

a. 9.02 kJ b. 16.9 kJ c. 34.2 kJ d. 39.2 kJ e. 78.1 kJ

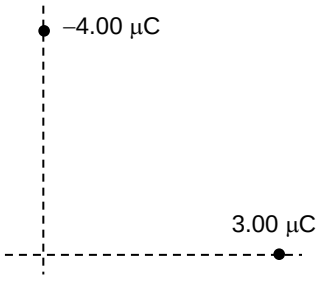
26. The function that describes the displacement, *y*, of a material carrying a wave in the *x*-direction is given by

$$y(x,t) = A\cos(3kx - 9\omega t) + 2A\sin(2kx - 6\omega t).$$

What is the velocity of the wave?

a. $A\omega$ b. $1.5A\omega$ c. $3A\omega$ d. Ak/ω^2 e. $3\omega/k$

27. A 3.00 μC charge is located at the position x = 20.0 cm, y = 0.00 cm. A –4.00 μC charge is located at the position x = 0.00 cm, y = 20.0 cm. What is the magnitude of the electric field at the origin?



a. 1.02×10^6 N/C
b. 1.12×10^6 N/C
c. 2.87×10^6 N/C
d. 5.23×10^6 N/C
e. 5.66×10^6 N/C

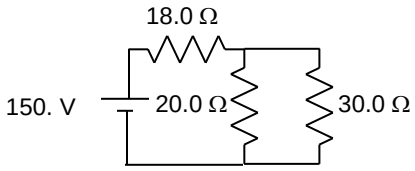
28. The electrostatic potential is 2.00 V at position A. There is a uniform electric field of magnitude 5.00 N/C pointing toward the north. What is the electrostatic potential at position B located 1.00 m north of position A?

a. −3.00 V
b. 2.00 V
c. 5.00 V
d. 7.00 V
e. 12.0 V

29. At some instant, a negative charge is moving upward toward the top of the page with velocity **v** in a magnetic field **B** that points toward the right, as shown. What is the direction of the magnetic force on the charge?

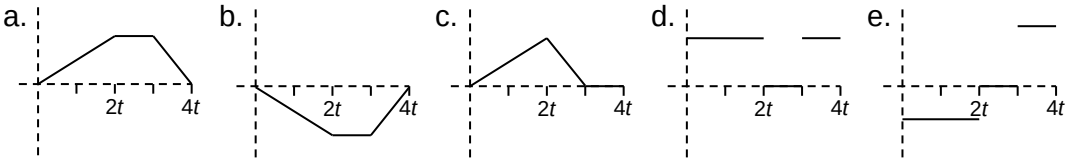
a. toward the left
b. to the right
c. out of the page
d. into the page
e. There is no magnetic force on the charge.

30. How much power is supplied to the circuit by the voltage source?



a. 150. W
b. 276 W
c. 450. W
d. 750. W
e. 998 W

31. The magnetic flux through a loop of wire increases from zero at a constant rate R for a time 2*t*, then remains constant for a time *t*, then decreases back to zero in a time *t*. Which plot best represents the induced EMF in the loop as a function of time?



32. A 3.00 mH inductor and a 40.0 Ω resistor are connected in series to a 10.0 V rms sinusoidal source with an angular frequency 1.00×10^4 s^{-1}. Determine the rms current that flows through the inductor.

a. 0.100 A b. 0.200 A c. 0.300 A d. 0.333 A e. 0.400 A

33. A 20.0 cm by 30.0 cm surface completely absorbs normally incident light of wavelength 600. nm at the rate of 2.00×10^{20} photons/s. What is the average intensity of the light aborbed by the surface?

a. 0.234 kW/m^2
b. 0.652 kW/m^2
c. 0.888 kW/m^2
d. 1.10 kW/m^2
e. 2.34 kW/m^2

34. An observer on the earth watches a spaceship pass by and measures its length in the direction of travel to be 75.0 m. An observer on the spaceship measures the length of the spaceship to be 100.0 m. What is the speed of the spaceship relative to the earth?

a. 0.563 *c* b. 0.661*c* c. 0.750*c* d. 0.866*c* e. 1.33*c*

35. When a ^{14}C atom undergoes beta decay, what is the resulting isotope?

a. ^{14}B b. ^{13}C c. ^{13}N d. ^{14}N e. ^{16}O