2017 Academic Challenge

PHYSICS TEST – STATE

– This Test Consists of 35 Questions –

Physics Test Production Team
Doug Brandt, Eastern Illinois University – Author/Team Leader
Steve Daniels, Eastern Illinois University – Author
Don Pakey, Eastern Illinois University - Reviewer
Sahid L. Rosado Lausell, 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. 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} $C^2/(N \cdot m^2)$
Electrostatic Constant	$k = (4\pi\epsilon_0)^{-1}$	8.988×10^{9} $N \cdot m^2/C^2$
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} $N \cdot m^2/kg^2$
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) – 2017

1. Which set of units is correct for a Young's modulus?

a. $\frac{kg \cdot m^2}{s^2}$ b. $\frac{kg \cdot m}{s^2}$ c. $\frac{kg \cdot m^2}{s}$ d. $\frac{kg}{s^2}$ e. $\frac{kg}{s^2 \cdot m}$

2. Given M = mass, L= length, and T = time, a quantity with dimensions $\frac{M}{T^3}$ could be

a. energy per length.
b. power per area.
c. energy per length per time.
d. momentum per time per time.
e. acceleration per length per time.

3. A person walks 4.00 miles east in 1.00 hours then walks 3.00 miles north in 45.0 minutes and finally walks from that position to the initial position in a straight line in 1 hour and 40.0 minutes What is the average speed for the round trip?

a. 0.00 mi/hr b. 3.51 mi/hr c. 3.67 mi/hr
d. 3.89 mi/hr e. 4.00 mi/hr

4. An object moving along a straight line has an initial velocity in the positive *x* direction with a speed 3.00 m/s and is slowing down with a constant magnitude acceleration 0.200 m/s^2. What distance does the object travel from its initial position until it has a velocity 1.00 m/s in the positive *x* direction?

a. 0.400 m b. 0.800 m c. 20.0 m d. 40.0 m e. 80.0 m

5. In the situation described in problem 4 and starting with the initial condition stated, how much time does it take the object to return to its initial position?

a. 1.00 s b. 2.00 s c. 10.0 s d. 20.0 s e. 30.0 s

6. A boat travels on a river with a velocity relative to the river bank 12.0 m/s east. The river water is flowing north with a speed 5.00 m/s. What is the speed of the boat relative to the river water?

a. 7.00 m/s b. 8.66 m/s c. 10.9 m/s d. 13.0 m/s e. 17.0 m/s

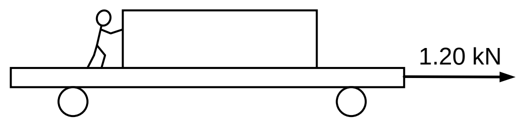
7. When an object is launched from the ground at an angle 50.0° above horizontal, it reaches a maximum height 30.0 m above the ground. How far does the object travel horizontally from its launch point before returning to the ground?

a. 48.7 m b. 56.3 m c. 60.0 m d. 76.2 m e. 101 m

8. In the situation described in problem 7, with what speed was the object launched?

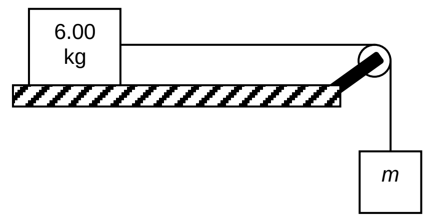
a. 15.6 m/s b. 18.6 m/s c. 24.2 m/s d. 31.7 m/s e. 37.7 m/s

9. A cart of mass 800. kg is pulled to the right with a force 1.20 kN. A 100. kg person on the cart pushes a 200. kg block toward the right so that the block and the person accelerate to the right at 2.00 m/s^2 relative to the ground. If the force of the ground on the cart is directed vertically, what is the magnitude of the acceleration of the cart?



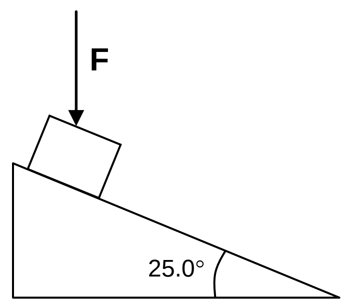
a. 0.750 m/s^2
b. 0.800 m/s^2
c. 1.00 m/s^2
d. 1.09 m/s^2
e. 1.50 m/s^2

10. An 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. 3.06 kg   b. 6.25 kg   c. 8.00 kg   d. 9.80 kg   e. 10.5 kg

11. A block with a weight 8.00 N slides down the frictionless 25.0° incline with an acceleration 6.00 m/s^2 parallel to and down the incline. A vertical downward force **F** is applied to the top surface of the block. What is the magnitude of force **F** on the block?



a. 3.59 N   b. 4.14 N   c. 19.6 N
d. 23.2 N   e. 67.7 N

12. In the situation described in problem 11, what is the magnitude of the additional force that needs to be applied to the block in a direction parallel to the incline so that the acceleration of the block is zero?

a. 0.750 N   b. 1.33 N   c. 4.90 N   d. 11.6 N   e. 48.0 N

13. Initially, a 3.00 kg object is travelling 4.00 m/s toward the east and a 2.00 kg object is travelling west at 3.00 m/s with the center of mass of the two objects located at the origin. At a time 2.00 s later, the two objects collide with a coefficient of restitution 0.800. Where is the center of mass of the two objects located 5.00 s after the initial conditions if no external forces act on the system?

a. 2.00 m east of the origin
b. 6.00 m east of the origin
c. 4.00 m west of the origin
d. 3.89 m 37.2° north of east of the origin
e. additional information is needed to solve this problem

14. A 5.00 kg object traveling East at 30.0 m/s collides perfectly elastically with an initially stationary 4.00 kg object. The 5.00 kg object is deflected so its speed is 10.0 m/s after the collision. What is the speed of the 4.00 kg object after the collision?

a. 31.6 m/s
b. 25.0 m/s
c. 24.0 m/s
d. 12.4 m/s
e. The problem cannot be answered unless the angle of deflection is known.

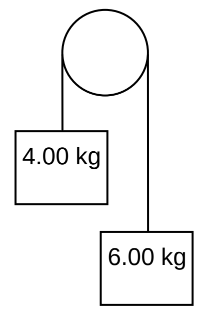
15. Which of the following lengths is equal to 10^{-12} m?

a. nanometer
b. pentameter
c. picometer
d. femtometer
e. attometer

16. A total 4.00 N·m torque acts on a 3.00 kg object that is constrained to rotate about a fixed axis through its center of mass. If the object begins at rest and after the torque acts for 12.0 s has a rotational kinetic energy of 600. J, what was the average power supplied to the object by the torque?

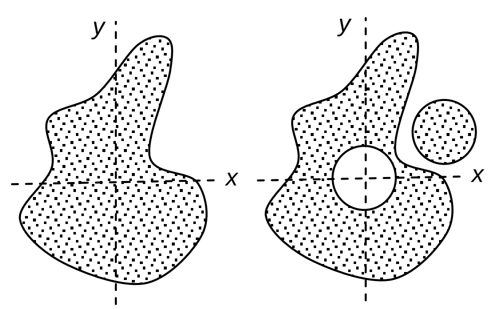
a. 4.17 W b. 50.0 W c. 85.7 W d. 144.0 W e. 150.0 W

17. As shown in the diagram, two masses are connected by an unstretchable string of negligible mass that runs over a frictionless pulley, also of negligible mass. What is the tension in the string?



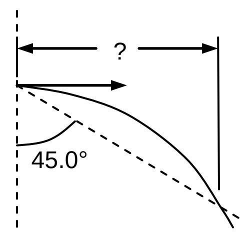
a. 28.6 N
b. 47.0 N
c. 65.4 N
d. 70.6 N
e. 98.0 N

18. The center of mass of the uniform density 12.0 kg object in the left diagram is located at the origin of the indicated coordinate system. A 2.00 kg circular piece of the object centered at the origin is cut out and its center is moved to x = 3.00 m, y = 2.00 m, as shown in the right diagram. What are the coordinates of the center of mass of the system after the cut out piece is moved?



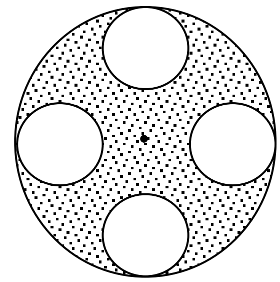
a. x = 3.00 m, y = 2.00 m
b. x = 1.00 m, y = 0.667 m
c. x = 0.600 m, y = 0.400 m
d. x = 0.300 m, y = 0.200 m
e. x = 0.500 m, y = 0.333 m

19. An object is thrown horizontally at a speed 30.0 m/s. How far horizontally has it travelled when it is located along a line directed 45.0° below horizontal from the point of release?



a. 47.6 m b. 98.0 m c. 122 m d. 184 m e. 245 m

20. A uniform flat circular plate of radius R has four circular cutouts of radius R/3 positioned 90.0° apart and centered 2R/3 from the center of the plate. The mass of this remaining object is M. What is the moment of inertia of this object about an axis perpendicular to the page through the center of the plate? The moment of inertia of a whole flat circular plate of radius r and mass m about an axis perpendicular to the plate and through its center is $\frac{1}{2}mr^2$.



a. $\frac{4}{9}MR^2$

b. $\frac{38}{81}MR^2$

c. $\frac{1}{2}MR^2$

d. $\frac{83}{162}MR^2$

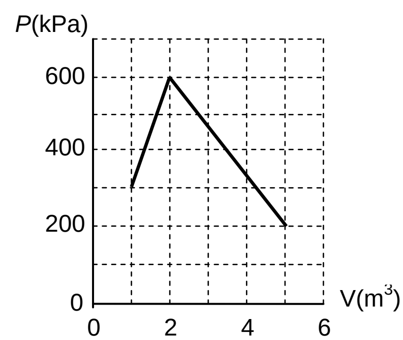
e. $\frac{115}{162}MR^2$

21. A planet is discovered orbiting a distant star at a distance of 6.00×10^8 km from the star with a period of 20.0 years. Assuming the planet's mass is much less than that of the star, what is the mass of the star?

a. 7.13×10^{18} kg   b. 3.21×10^{29} kg   c. 5.46×10^{31} kg

d. 6.78×10^{32} kg   e. 2.26×10^{33} kg

22. An ideal gas with an initial absolute pressure 300. kPa and volume 1.00 m^3 is taken by the process indicated on the graph to the final pressure 200. kPa and volume 5.00 m^3. If the initial absolute temperature is T, what is the final temperature?

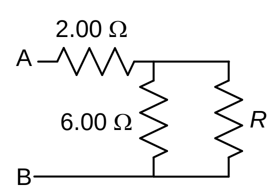


a. 0.300T
b. 1.00T
c. 3.33T
d. 4.00T
e. 5.00T

23. In the situation described in problem 22, how much work was done by the gas on the environment during the process?

a. 6.00×10^5 J   b. 7.00×10^5 J   c. 1.00×10^6 J
d. 1.20×10^6 J   e. 1.65×10^6 J

24. The equivalent resistance between nodes A and B of the network shown is 4.00 Ω. What is the resistance of resistor R?



a. 0.00 Ω
b. 2.00 Ω
c. 3.00 Ω
d. 4.00 Ω
e. 5.00 Ω

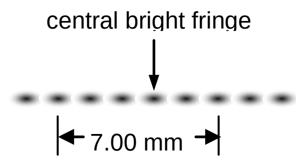
25. Three circuit elements are connected in series, a 9.00 Ω resistor, a 20.0 μF capacitor, and a 30.0 mH inductor. What is the magnitude of the equivalent impedance of this series network at an angular frequency, $\omega = 1.20 \times 10^3\ s^{-1}$?

a. 3.33 Ω b. 10.6 Ω c. 14.0 Ω d. 14.7 Ω e. 86.7 Ω

26. On planet X, a 2.00 kg object with a charge of 3.00 mC is levitated and held in equilibrium by an applied electric field. If the magnitude of the electric field required to create the levitation is 4000. V/m, what is the gravitional acceleration at this location?

a. 1.98 m/s^2 b. 2.67 m/s^2 c. 3.33 m/s^2 d. 6.00 m/s^2 e. 26.7 m/s^2

27. Light of wavelength 500. nm passes through a pair of slits, incident from a direction perpendicular to the plane of the slits. The light passing through the slits illuminates a screen placed 3.00 m from the slits. The bright finge second to the right of the central bright fringe is 7.00 mm away from the third bright fringe to the left of the central bright fringe. What is the center-to-center separation of the two slits?

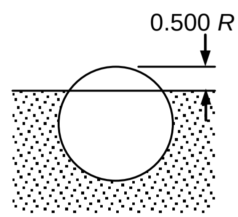


a. 1.28 mm b. 1.07 mm c. 0.988 mm d. 0.536 mm e. 0.502 mm

28. A two thin lens system is used to create a real image on a screen that is located at x = 2.00 m. The first lens has a focal length +40.0 cm and is located at x = 10.0 cm. The second lens has a focal length –80.0 cm and is located at x = 60.0 cm. What is the x position of the source for which the configuration will form real images of the source on the screen?

a. –56.3 cm b. –33.8 cm c. –23.2 cm d. –5.75 cm e. +5.75 cm

29. A right circular cylinder of radius R floats with the top 0.500 R above the surface of the fluid of density ρ in which it is floating. What is the density of the cylinder?



a. 0.500ρ b. 0.767ρ c. 0.804ρ d. 0.902ρ e. 1.23ρ

30. An incompressible, non-viscous fluid undergoes laminar flow through a horizontal circular cross-section conical duct that tapers from a radius 20.0 cm down to a radius 10.0 cm. At the large radius end, the pressure in the fluid is $2.00 \times 10^5\ N/m^2$ greater than the pressure at the small radius end. The speed of the fluid flow at the large end is 40.0 m/s. What is the density of the fluid?

a. 1.29 kg/m^3 b. 16.7 kg/m^3 c. 188 kg/m^3
d. 1000 kg/m^3 e. 3333 kg/m^3

31. Given a fixed amount of an ideal gas held at absolute temperature T, an amount of heat Q is added to gas while the gas expands and does an amount of work W on the environment. What is the change in entropy of the gas?

a. $\frac{Q+W}{T}$ b. $\frac{W-Q}{T}$ c. $\frac{Q-W}{T}$ d. $\frac{QW}{T}$ e. $\frac{Q}{T}$

32. A 50.0 kg block at 40.0 °C is dropped from rest from a height of 20.0 m above the ground. The material the block is made of has a specific heat 80.0 J/(kg·C°). If all of the block's kinetic energy at the moment of collision with the ground is converted into internal energy of the block, what will be the temperature of the block immediately after the collision?

a. 42.5 °C b. 43.1 °C c. 44.7 °C d. 45.1 °C e. 47.7 °C

33. A quantum mechanical system absorbs two photons successively, one of wavelength 400. nm and one of wavelength 600. nm. How much has the energy of the system increased?

a. 1.24 eV b. 1.78 eV c. 3.56 eV d. 4.00 eV e. 5.17 eV

34. The energy of a particle of mass m is Amc^2. What is the kinetic energy of the particle?

a. $\frac{1}{2}mc^2$ b. $(A-1)mc^2$ c. Amc^2
d. $(A+\frac{1}{2})mc^2$ e. $(A+1)mc^2$

35. Which of the following is a subatomic particle that is unstable with a half-life 611 s?

a. electron b. proton c. neutron d. prion e. alphon