2018 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. 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	$k = (4\pi\varepsilon_0)^{-1}$	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 ^oC = 273.15 K

WYSE – Academic Challenge
Physics Test (State) – 2018

1. Given the following pairs of physical quantities, in which pair do both quantities have the same dimensions?

   a. angular momentum, intensity
   b. power, moment of inertia
   c. velocity, angular acceleration
   d. energy, angular momentum
   e. work, torque

2. Given 1.00 inch = 2.54 cm, what is a speed of 30.0 km/hr in units of inches/second?

   a. 28.2 inches/second
   b. 47.6 inches/second
   c. 328 inches/second
   d. 833 inches/second
   e. 987 inches/second

3. Both starting from the same point, student A walks 600. m directly east and student B walks 800. m directly north. What is the displacement of student B from student A after they complete their walks?

   a. 1000. m 36.9° west of north   b. 1000. m 36.9° east of south
   c. 1000. m 53.1° west of north   d. 1000. m 53.1° west of south
   e. 1.40 km 53.1° east of south

4. A speeding vehicle travelling in a straight line at 40.0 m/s passes a highway patrol car at rest. The patrol car accelerates at a constant 3.00 m/s^2 in the direction of the car's velocity immediately after the speeding vehicle reaches the patrol car. How much time does it take the patrol car to catch up to the speeding vehicle?

   a. 18.5 s   b. 23.8 s   c. 26.7 s   d. 31.4 s   e. 32.9 s

5. A tanker is travelling at 20.0 knots on a heading 30.0° east of north. A destroyer is approaching the path of the tanker at 30.0 knots on a heading 45.0° south of west. What is the relative velocity of the destroyer toward the tanker?

   a. 49.6 knots 51.1° south of west
   b. 37.8 knots 42.3° south of west
   c. 29.9 knots 67.7° south of west
   d. 24.6 knots 38.8° south of west
   e. 10.0 knots 15.0° south of west

6. A stone is thrown vertically upward with a speed of 20.0 m/s from a height of 2.00 m above the surface of the earth. If it remains in free-fall, how much time will it take until it strikes the earth?

   a. 2.09 s   b. 3.16 s   c. 3.56 s   d. 4.18 s   e. 6.37 s

7. In the situation described in problem 6, what is the maximum height above the earth reached by the object?

   a. 15.6 m   b. 20.4 m   c. 22.4 m   d. 31.6 m   e. 37.7 m

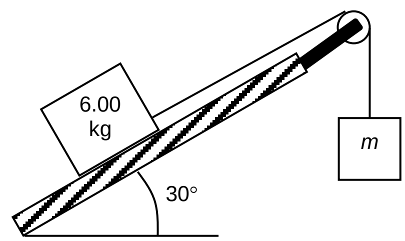
8. An object moves in rectilinear motion along the x axis. Its position as a function of time is given by

$$x(t) = 3.00\text{ m} + (6.00\text{ m/s})\,t + (2.00\text{ m/s}^2)\,t^2$$

   What is the acceleration of the object?

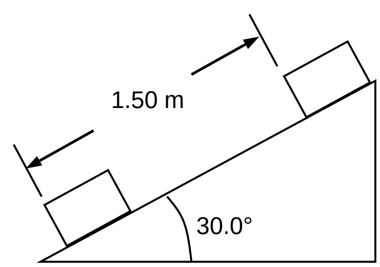
   a. 6.00 m/s^2 b. 4.00 m/s^2 c. 2.00 m/s^2 d. 1.00 m/s^2 e. 0.00 m/s^2

9. A 6.00 kg block on a frictionless surface tilted 30.0° to horizontal 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 acceleration of the 6.00 kg mass is 2.00 m/s^2 up the plane, what is the mass *m*?



   a. 3.06 kg   b. 5.31 kg   c. 8.00 kg   d. 9.80 kg   e. 10.5 kg

10. The 3.00 kg block is sliding down the 30.0° incline. At the upper position it has a speed 1.00 m/s. When it reaches the lower position, its speed is 3.00 m/s. What is the coefficient of kinetic friction between the block and the incline?



   a. 0.111   b. 0.263   c. 0.312
   d. 0.333   e. 0.500

11. The drag force on a 2.00 kg parachute with a drag coefficient C_d of 0.800 and an area A of 30.0 m^2 is given by

$$F_{parachute} = \frac{1}{2} C_d \rho A v^2$$

   where ρ is the density of air (1.29 kg/m^3) and v is the speed of the parachute. Ignoring all drag forces except that on the parachute, what is the magnitude of the acceleration of an 78.0 kg person wearing the parachute while falling vertically at a speed of 20.0 m/s?

   a. 9.80 m/s^2 b. 24.2 m/s^2 c. 36.3 m/s^2 d. 42.2 m/s^2 e. 67.6 m/s^2

12. In the situation described in problem 11, what is the terminal velocity of the person wearing the parachute?

   a. 1.44 m/s   b. 1.78 m/s   c. 3.56 m/s   d. 7.12 m/s   e. 9.44 m/s

13. Initially, a 4.00 kg object is travelling 2.00 m/s toward the east and a 3.00 kg object is travelling west at 4.00 m/s with the center of mass of the two objects located at the origin. At a time 3.00 s later, the two objects collide with a coefficient of restitution 0.800. Where is the center of mass of the two objects located 6.00 s after the collision if no external forces act on the system?

a. 3.43 m west of the origin
b. 5.14 m west of the origin
c. 3.43 m east of the origin
d. 25.7 m east of the origin
e. at the origin

14. A perfectly elastic collision is one in which the

a. kinetic energy of each colliding object is the same after the collision as before.
b. momentum of each colliding object is the same after the collision as before.
c. velocity of each colliding object is the same after the collision as before.
d. total velocity of all colliding objects is the same after the collision as before.
e. total kinetic energy of all colliding objects is the same after the collision as before.

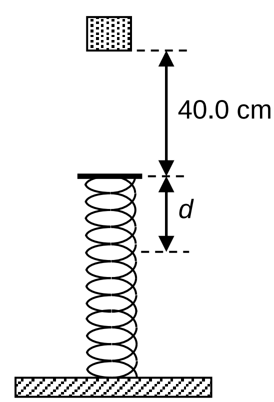
15. Which of the following energies is equal to a TeV?

a. 10^{-15} eV b. 10^{-12} eV c. 10^{-10} eV d. 10^{12} eV e. 10^{15} eV

16. An object constrained to move in a circular path of radius 25.0 m is moving at an instantaneous speed 10.0 m/s while its speed is increasing at a rate of 3.00 m/s^2. What is the magnitude of the instantaneous acceleration of the object?

a. 1.00 m/s^2 b. 3.00 m/s^2 c. 4.00 m/s^2 d. 5.00 m/s^2 e. 7.00 m/s^2

17. A 3.000 kg block is released from rest from a distance 40.0 cm above the top, free end of a vertically oriented spring of spring constant 2000. N/m. The bottom end of the spring is fixed to an immoveable, horizontal surface. What will be the maximum distance, *d*, the spring is compressed by the block, assuming the spring's natural length is greater than *d*?

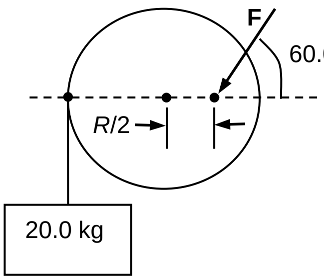


a. 10.8 cm
b. 12.4 cm
c. 23.6 cm
d. 28.1 cm
e. 29.7 cm

18. The center of mass of an object is at rest. The object explodes and splits into three fragments. The first fragment has a mass 3.00 kg and an initial velocity after the explosion (200. m/s, 300. m/s, 200. m/s). The second fragment has a mass 2.00 kg and an initial velocity (100. m/s, –400. m/s, –200. m/s). The third fragment has a mass 4.00 kg. What is the initial velocity of the third fragment after the explosion?

a. (–200. m/s, –25.0 m/s, –50.0 m/s)
b. (–200. m/s, 25.0 m/s, 250. m/s)
c. (200. m/s, –25.0 m/s, –300. m/s)
d. (200. m/s, 25.0 m/s, –250.0 m/s)
e. (200. m/s,. –425 m/s, –100. m/s)

19. A 4.00 kg disk of radius *R* is free to rotate about a frictionless axle through its center. A 20.0 kg mass is suspended from a point on the edge of the disk and a force **F** acts at a point a distance *R*/2 from the center of the disk in the 60.0° direction shown in the diagram. If the disk is in static equilibrium, what is the magnitude of force **F**?



a. 23.1 N b. 46.2 N c. 226 N
d. 392 N e. 453 N

20. An object of mass 2.00 kg has a moment of inertia 0.800 kg·m^2 for an axis of rotation through its center of mass and parallel to the *z* axis. The object has a moment of inertia 1.200 kg·m^2 for an axis of rotation a distance *d* from the center of mass and parallel to the z axis. What is the distance *d*?

a. 0.200 m b. 0.447 m c. 0.667 m d. 0.823 m e. 1.00 m

21. A planet has a spherically distributed mass that is 4.00 times the mass of the earth, but has a gravitational acceleration at its surface that is equal to the gravitational acceleration at the surface of the earth. If the radius of the earth is R_e, what is the radius of the planet?

a. 0.250R_e b. 0.500R_e c. 2.00R_e d. 4.00R_e e. 16.0R_e

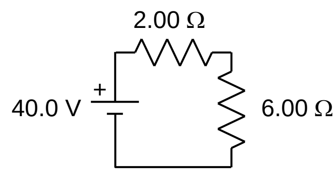
22. A non-viscous, incompressible fluid with a density 5.00 × 10^3 kg/m^3 flows with laminar flow through a uniform cross-section pipe. At a location where the pipe is 2.00 m above the level ground, the absolute fluid pressure is 200. kPa. What is the absolute pressure in the fluid at a location where the pipe is 8.00 m below ground?

a. –800. kPa b. –600. kPa c. 490 kPa
d. 690 kPa e. 800. kPa

23. What is the amplitude of the voltage across an ideal 50.0 mH inductor that is carrying a sinusoidal current of angular frequency 80.0 s^{-1} and amplitude 2.00 A?

a. 2.00 V b. 4.00 V c. 8.00 V d. 16.0 V e. 32.0 V

24. In the circuit shown in the diagram, what is the magnitude of the voltage drop across the 6.00 Ω resistor?.



a. 6.00 V b. 10.0 V c. 20.0 V
d. 30.0 V e. 40.0 V

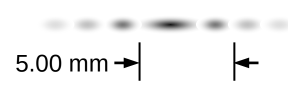
25. Two charges are located on the x-axis. A 20.0 µC charge is located at x = 40.0 cm and a –50.0 µC charge is located at x = –60.0 cm. What is the x-component of the electric field at the origin?

a. -1.25×10^5 N/C b. 1.25×10^5 N/C
c. -1.20×10^6 N/C d. -2.38×10^6 N/C
e. 2.38×10^6 N/C

26. In the situation described in problem 25, what would be the change in electrical potential energy of the system if a 30.0 µC charge is moved along the x-axis from x = 10.0 cm to x = 70.0 cm?

a. 1.67 J b. 3.22 J c. 3.87 J d. 8.90 J e. 9.72 J

27. Light of wavelength 600. nm passes through a single slit and forms a diffraction pattern on a screen 2.00 m from the slit. The first diffraction minimum to the left of the central maximum is 5.00 mm away from the second diffraction minimum to the right of the central maximum. What is the width of the slit?



a. 480. µm b. 720. µm c. 960 µm d. 0.1.44 mm e. 2.88 mm

28. A source of light is located 20.0 cm from a +30.0 cm focal length lens. What is the linear magnification of the image formed by this configuration of source and lens?

a. –0.667 b. 0.667 c. 1.50 d. 2.00 e. 3.00

29. A heat source is embedded within an insulated container filled with 2.00 kg of a fluid. The temperature of the fluid is observed to increase at a rate of 2.00 °C per minute. Given that the specific heat of the fluid is 800. J/kg/C°, what is the power output of the heat source?

a. 0.300 W b. 3.33 W c. 13.3 W d. 53.3 W e. 3.20 kW

30. A single horizontal circular loop of wire of radius 20.0 cm rests in a uniform magnetic field of magnitude 3.00 T pointing vertically downward. The magnitude of the magnetic field decreases to zero at a uniform rate in 40.00 ms. What is the induced EMF in the loop during the time the field is changing?

a. 0.300 V b. 1.50 V c. 3.14 V d. 6.28 V e. 9.42 V

31. 3.00 moles of an ideal gas is intially at temperature *T*, volume *V*, and pressure *P*. The gas is isothermally expanded to a volume 2.00*V*. What is the pressure of the gas after being expanded?

    a. 0.250*P*
    b. 0.500*P*
    c. 1.00*P*
    d. 2.00*P*
    e. The question cannot be answered unless the temperature after expansion is given.

32. If the gas in problem 31 is monatomic, what is the change in internal energy of the gas during the expansion?

    a. zero b. *PV* c. 3.00*PV* d. 4.50*PV* e. 9.00*PV*

33. Which of the following phenomena cannot be explained in terms of purely classical physics, but require the introduction of quantum physics?

    a. blackbody radiation
    b. Compton scattering
    c. electron diffraction
    d. photoelectron emission
    e. all of the above

34. A spaceship is passing by an observer on earth and that observer measures the length of the spaceship to be 60.0 m in length along the direction of motion. A passenger on the spaceship measures that length to be 80.0 m. What is the speed of the spaceship relative to the earth?

    a. 0.250*c* b. 0.563*c* c. 0.661*c* d. 0.750*c* e. 0.866*c*

35. An isotope has a half-life $T_{1/2}$. What is the probability per unit time that any one specified nucleus of the isotope decays?

    a. $T_{1/2}$ b. $1/T_{1/2}$ c. $\ln 2 \cdot T_{1/2}$ d. $\log_{10} 2 \cdot T_{1/2}$ e. $\ln 2 / T_{1/2}$