2018 Academic Challenge

PHYSICS TEST – REGIONAL

– This Test Consists of 35 Questions –

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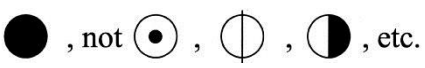
GENERAL DIRECTIONS

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 

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	$k = (4\pi\epsilon_0)^{-1}$	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 (Regional) – 2018

1. Air quality is often measured in units of micrograms per cubic meter. Which of the following has the same dimensions as air quality?

   a. $\frac{\text{Energy}}{(\text{Time})^2}$
   b. $\frac{\text{Pressure}}{(\text{Velocity})^2}$
   c. $\frac{\text{Force}}{\text{Volume}}$
   d. $\frac{\text{Force}(\text{Time})^2}{\text{Area}}$
   e. $\text{Power}(\text{Velocity})(\text{Time})^4$

2. A rabbit is crossing a field. The rabbit runs at 11.4 m/s for 1.48 seconds, then slows to 0.54 m/s for 25.3 seconds, then scoots to the other side of the field at 16.1 m/s for 0.30 seconds. How far did the rabbit go in crossing the field?

   a. 4.90 m b. 12.0 m c. 16.9 m d. 28.0 m e. 35.4 m

3. An individual is riding in an elevator going up. When the elevator starts out there is an acceleration of 0.800 m/s^2. What is the normal force acting on a 43.0 kg person in this elevator during that acceleration?

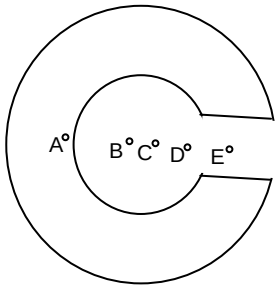
   a. 34.0 N b. 387 N c. 421 N d. 456 N e. 527 N

4. After the elevator has completed its acceleration, the elevator in the previous problem cruises at a constant speed upward of 2.80 m/s. The normal force experienced by the person during this portion of the trip is:

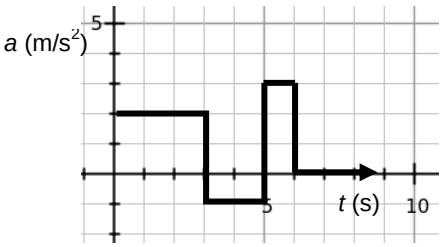
   a. 0 N b. 120 N c. 387 N d. 421 N e. 456 N

5. The object shown is a uniform sheet in the shape of a C. Which labelled point is closest to the center of mass of this object?

   a. A b. B c. C
   d. D e. E



6. The graph shows acceleration vs time for a particle. The particle starts from rest at time 0.00 seconds. What is the velocity at 9.00 seconds?



   a. 0 m/s b. 4 m/s c. 7 m/s
   d. 11 m/s e. 54 m/s

7. Consider the vectors:

   $\mathbf{V_1}$ = 3.00 at 140˚ from positive x axis
   $\mathbf{V_2}$ = 2.05 at 250˚ from positive x axis

   What is $\mathbf{V_1} + \mathbf{V_2}$?

   a. 3.00 at 180˚
   b. 0.95 at 110˚
   c. 0.95 at 195˚
   d. 4.89 at 128˚
   e. 2.66 at 82˚

8. A cannon fires a 3.2 kg cannonball horizontally from a height of 1.1m above the level ground. The cannonball lands 142 m from the cannon. What impulse is given to the cannon by firing the cannonball?

   a. 0.654 kg m/s
   b. 119 kg m/s
   c. 300 kg m/s
   d. 374 kg m/s
   e. 959 kg m/s

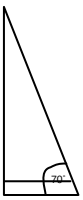
9. Tides are principally caused by:

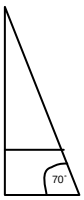
   a. The difference in gravitation pull from the moon on the near and far sides of the earth.
   b. The difference in gravitational pull from the sun on the near and far sides of the earth.
   c. The orbital motion of the moon around the earth.
   d. The rotational inertia of the water in the oceans.
   e. The global prevalence of easterly winds.

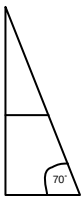
10. A ball is thrown upward with an initial velocity of 14.5 m/s from the edge of the roof of a tall building such that it falls and lands 38.0 m below the point it was thrown from. What is the downward velocity of the ball when it hits the ground below?

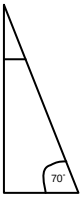
   a. 16.4 m/s b. 27.3 m/s c. 30.9 m/s d. 33.8 m/s e. 953 m/s

11. Consider a ladder 4.5m long with a mass of 9.8kg. It is leaning against a frictionless wall and on a frictionless floor. There is a horizontal string attached to the wall that creates the tension necessary to keep the ladder in place. Which position of the string will maintain equilibrium while producing the least tension in the string?

a. 

b. 

c. 

d. 

e. The tension in all of the strings will be the same.

12. Consider a board balanced on a fulcrum as follows. A mass of 15.7 kg placed 50.0 cm from one end of the 4.2 m long uniform board of mass 5.8 kg. In this configuration the board is in balance on the fulcrum. What is the distance from the mass to the fulcrum?

a. 0.43 m b. 0.93 m c. 1.30 m d. 2.40 m e. 10.0 m

13. A frictionless inclined plane makes an angle of 22.0˚ with the horizontal. A 750 g block is projected up this incline with an initial velocity of 1.18 m/s. After 19 cm the block briefly comes to rest. At that point the acceleration of the block is

a. 0.00 m/sec^2
b. 3.67 m/sec^2 down the incline
c. 9.80 m/sec^2 downward
d. 3.67 m/sec^2 up the incline
e. 1.18 m/sec^2 down the incline

14. The earth is rotating on its axis with an angular velocity of 7.27×10^{-5} rad/sec. Due to this rotation, a person standing still on the equator has a speed of 464 m/s. What is the speed of a person at the 40.0˚ north latitude due to the rotation of the earth?

a. 298 m/s b. 309 m/s c. 355 m/s d. 464 m/s e. 606 m/s

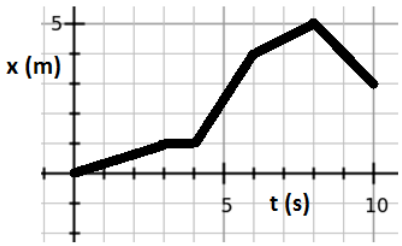
15. What factor is equivalent to the SI unit system prefix “nano” ?

a. 10^{-3} b. 10^{-6} c. 10^{-9} d. 10^{-12} e. 10^{-15}

16. Baseball great Mickey Mantle hits a ball with initial velocity 30.0 m/s at 45.0˚ above horizontal from home plate toward center field. The ball is caught by the great Willie Mays in center field. Willie throws to Jackie Robinson at second base. If it takes Willie 0.50 seconds to catch and throw the ball and he can throw with an initial velocity of 22.81 m/s at 45.0˚, how much time elapses from when Mickey hit it until Jackie catches it at second base? (For simplicity, assume all initial velocities start at the same height and are caught at the same height.)

a. 4.33 s b. 5.39 s c. 5.89 s d. 7.62 s e. 8.12 s

17. Consider the graph of an object's position vs time shown below. What is the magnitude of the average velocity of the object between the time 3 seconds and 10 seconds?

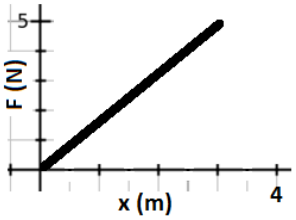


a. 0.286 m/s b. 0.300 m/s c. .667 m/s
d. 1.00 m/s e. 3.33 m/s

18. A car has a total mass of 528 kg and is travelling with a speed of 17.7 m/s. The driver slams on the brakes to avoid an accident. The wheels lock and the car comes to a stop in 34.1 m. What is the coefficient of friction between the tires and the road?

a. 0.117 b. 0.260 c. 0.319 d. 0.469 e. 0.519

19. Consider this graph of force vs position for an object of mass 1.50 kg. What is the work done in going from x = 0.00 m to x = 3.00 m?

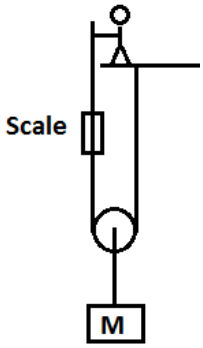


a. 0.600 J b. 1.40 J c. 7.50 J
d. 10.0 J e. 15 J

20. A 7.25 kg bowling ball travelling at 4.12 m/s collides head on with a 1.50 kg stationary bowling pin. Immediately after the colinear collision the ball is measured to have a speed of 2.71 m/s. What is the speed of the pin after the elastic collision?

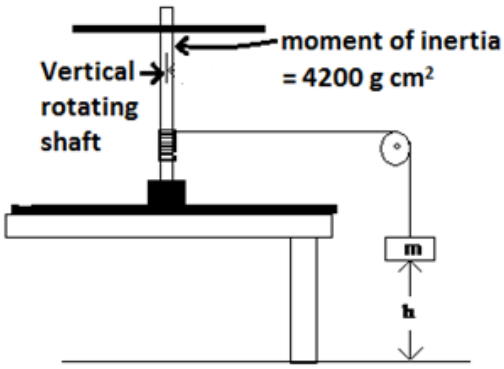
a. 0.29 m/s b. 1.95 m/s c. 2.93 m/s d. 6.82 m/s e. 46.5 m/s

21. A 20.0 kg mass is attached to a massless, frictionless pulley. The pulley is suspended from a platform as shown. The person pulls upward on the massless rope so that the mass moves upward at a constant speed. There is a scale attached to the rope in such a way that it measures the force of tension in the rope. What is the reading on the scale?



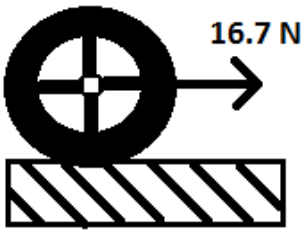
a. 0.00 N b. 65.0 N c. 98.0 N
d. 196 N e. 392 N

22. Consider the rotational motion apparatus shown in the figure. The moment of inertia of the vertical rotating shaft system is 4200 g·cm^2. The system starts from rest with the mass, m = 200 g, at a height of h = 76.0 cm above the floor. The string is wound around the shaft of radius 0.650 cm so that as the mass moves it unwinds without slipping, causing the shaft to spin. When the mass reaches the floor, what will be its speed?



a. 13.4 cm/s b. 54.2 cm/s c. 84.2 cm/s
d. 323 cm/s e. 386 cm/s

23. A constant, horizontal force of 16.7 N acts upon a wheel of mass 21.3 kg and a diameter of 0.825 m, causing it to accelerate on a horizontal surface without slipping at a rate of 0.411 m/s^2. What is the magnitude of the frictional force acting on the wheel?

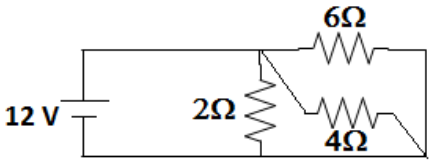


a. 0.862 N b. 6.86 N c. 7.95 N
d. 8.75 N e. 25.5 N

24. For the same situation described in problem 23, what is the angular acceleration of the wheel?

a. 0.411 rad/s
b. 0.498 rad/s
c. 0.546 rad/s
d. 0.825 rad/s
e. 0.996 rad/s

25. What is the current through the 6 Ω resistor?



a. 0.500 A b. 1.00 A c. 2.00 A
d. 11.0 A e. 13.1 A

26. If the potential energy is given by $U = axy^2z^3$ where a is a constant, what is the force that is created by this potential?

a. $-ay^2z^3\hat{x} - axz^3\hat{y} - axy^2\hat{z}$
b. $-ay^2z^3\hat{x} - 2axyz^3\hat{y} - 3axy^2z^2\hat{z}$
c. $-ax\hat{x} - ay^2\hat{y} - az^3\hat{z}$
d. $-6ayz^2\hat{x} - 6ayz^2\hat{y} - 6ayz^2\hat{z}$
e. $-a\hat{x} - 2ay\hat{y} - 3az^2\hat{z}$

27. A 850 kg Cessna 172 airplane has an engine that is capable of producing 2090 N of thrust while traveling at 51.4 m/s. What is the power output of this engine in that situation?

    a. 5.37×10^4 W
    b. 1.07×10^5 W
    c. 2.14×10^5 W
    d. 4.28×10^5 W
    e. 1.12×10^6 W

28. A point source generates a sound with intenity 2.5×10^{-6} W/m^2 measured 12.0 m from the source. The speed of sound on this hot day is 347 m/s. An observer is 185 m from the source. What sound intensity level (in Decibels) does the observer hear?

    a. 18.6 dB b. 40.2 dB c. 52.1 dB d. 64.0 dB e. 92.6 dB

29. Neptunium is a radioactive material with a density of 19.5 g/cm^3. It takes about 60 kg of Neptunium to sustain a nuclear chain reaction. What is the radius of a sphere of Neptunium that would sustain a nuclear chain reaction?

    a. 0.902 cm b. 0.990 cm c. 1.94 cm d. 3.13 cm e. 9.02 cm

30. An object that is 7.2 cm tall is placed a distance from a diverging lens. The lens produces an image that is 12.0 cm from the lens and 1.5 cm tall. What is the focal length of the lens?

    a. –15.2 cm b. –9.93 cm c. 3.16 cm d. 4.5 cm e. 9.93 cm

31. Who is credited with developing a law which states:

    "The induced voltage in a coil is proportional to the product of its number of loops, the cross sectional area of each loop, and the rate at which the magnetic field changes within those loops."

    a. Nikola Tesla
    b. Thomas Edison
    c. Marie Curie
    d. Michael Faraday
    e. Andre Marie Ampere

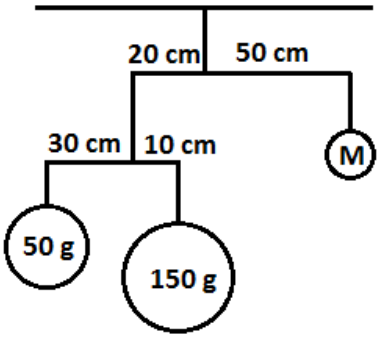
32. Which of the following particles are not hadrons?

    a. pions and omega particles
    b. protons and neutrons
    c. sigma particles and kaons
    d. lambda particles and upsilon particles
    e. electrons and muons

33. A constant mass of monatomic ideal gas expands from 2.50 m^3 to 7.50 m^3 at a constant pressure of 2.30×10^5 Pa. If the change in internal energy of the gas during this process is 1.73×10^6 J, how much heat was added to the gas during the process?

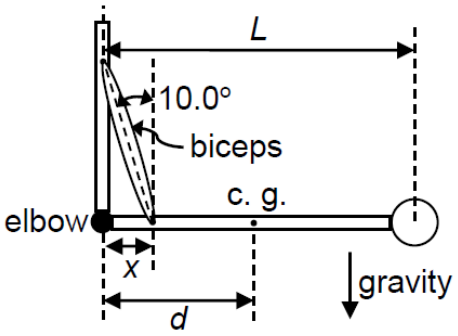
    a. -2.00×10^5J
    b. 2.00×10^5 J
    c. 1.15×10^6 J
    d. 2.88×10^6 J
    e. 3.15×10^6 J

34. Consider the mobile shown in the diagram. With the lengths and masses as shown and the strings and support rods massless, what is the mass M that will balance the mobile?



    a. 50 g b. 80 g c. 100 g
    d. 200 g e. 600 g

35. A man holds a 112.0 N ball in his hand, with his forearm horizontal and his upper arm vertical, as shown. The man's forearm weighs 32.0 N. The following distances along the forearm have been measured:



    x = 0.0470 m (elbow to biceps connection)
    d = 0.150 m (elbow to center of gravity of forearm)
    L = 0.320 m (elbow joint to ball's center of gravity)

    Assuming that the biceps muscle makes an angle of 10.0° to the vertical, what is the magnitude of the force that the biceps exerts on the forearm?

    a. 45 N b. 774 N c. 865 N d. 878 N e. 4970 N