2016 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. 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 °C = 273.15 K

WYSE – Academic Challenge
Physics Test (Regional) – 2016

1. Torque has the same units as work, but is different in what important way?

a. Torque is a vector quantity, while work is not.
b. Work is a vector quantity, while torque is not.
c. Torque comes solely from action at a distance forces, while work can come from contact forces.
d. Torque is always a conserved quantity, while work may or may not be conservative.
e. Torque applies to rotational motion systems, while work does not.

2. Young's Modulus is measured in Pascals. It can be defined as some function of force (F), area (A), initial length (L_o), and change in length (ΔL). Which expression is dimensionally consistent with the units of Young's Modulus?

a. $FA\ \Delta L\ L_o$ b. $FA\ (L_o/\Delta L)$ c. $F\ L_o\ (\Delta L\ /\ A)$ d. $(F/A)\ (L_o/\ \Delta L)$ e. $(A/F)\ (L_o/\ \Delta L)$

3. Beginning from rest, a grindstone rotates through an angle of 6.20 revolutions in a time of 12.0 s. Assuming that the angular acceleration of the wheel was constant during this interval of time, what was the magnitude of this angular acceleration in rad/s^2?

a. 0.086 b. 0.517 c. 0.541 d. 0.689 e. 1.08

4. A cubic container that is 7.00 cm on each side is completely filled with a liquid that has a mass of 1.00 kilogram. The density of the liquid is most closely

a. 0.0286 N/m^3. b. 343. kg/m^3. c. 2000 kg/m^3.
d. 2.92×10^3 kg/m^3. e. 2.86×10^4 N/m^3.

5. A force vector of magnitude 3.20 N is directed at an angle of 53.0˚ counterclockwise from the positive x axis. The Cartesian components of this vector are

a. F_x = 3.20 N and F_y = 53.0 N. b. F_x = 2.56 N and F_y = 1.93 N.
c. F_x = 1.60 N and F_y = 1.60 N. d. F_x = 0.00 N and F_y = 3.20 N.
e. F_x = 1.93 N and F_y = 2.56 N.

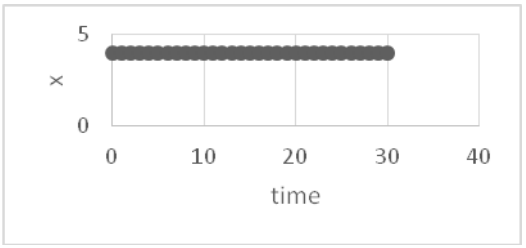
6. A ball is thrown straight upward. At the highest point of its flight

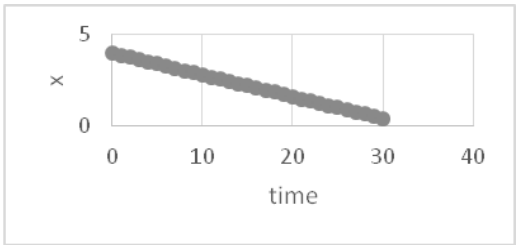
a. the acceleration is 9.8m/s^2 downward and the velocity is 0.0 m/s.
b. the acceleration is 0.0 m/s^2 and the velocity is 0.0 m/s.
c. the acceleration is 9.8m/s^2 upward and the velocity is 9.8 m/s upward.
d. the acceleration is 9.8m/s^2 downward and the velocity is 9.8 m/s downward.
e. the acceleration is 0.0 m/s^2 and the velocity is 9.8 m/s downward.

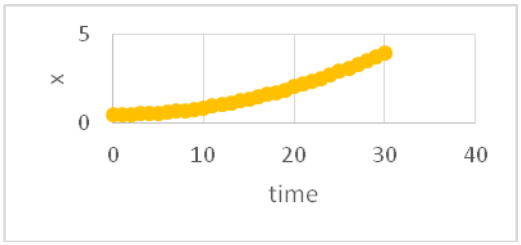
7. A stone is dropped from rest into a very deep well. The well is 207 m deep. The time from release of the stone until the sound of the splash of the rock hitting the water is heard by the person that dropped the stone is (Ignore air drag on the stone and assume the speed of sound to be 343 m/s.)

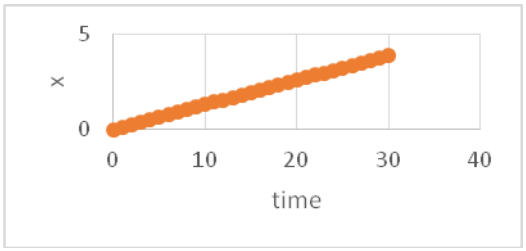
a. 0.60 s b. 1.21 s c. 6.50 s d. 7.10 s e. 13.0 s

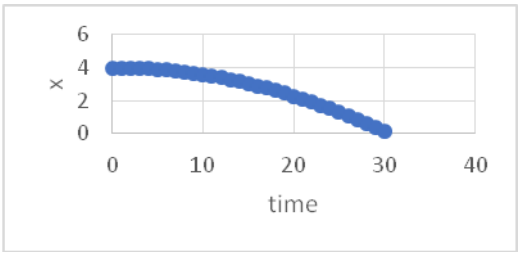
8. Which of the following graphs shows the component of velocity in the x direction decreasing with time?

a.


b.


c.


d.


e.


9. A 5.0 kg block slides across a floor with a coefficient of kinetic friction between the block and the floor of 0.35. The block has a velocity of 4.62 m/s at the beginning. After the block slides 1.8 m, what is its velocity?

a. 2.5 m/s b. 3.0 m/s c. 3.5 m/s d. 3.7 m/s e. 6.3 m/s

10. A small 250.-g mass is suspended by a light string of length 1.00 m. The mass is then set in a circular motion in a horizontal plane so that the string maintains a constant angle of 15.0˚ from the vertical. The speed of the mass necessary to accomplish this is 0.824 m/s. What is the angular momentum of the mass with respect to the vertical axis through the pivot point?

a. 0.053 kg m^2/s b. 0.085 kg m^2/s c. 0.206 kg m^2/s
d. 0.796 kg m^2/s e. 1.27 kg m^2/s

11. A uniform 750 g disk of radius 15 cm rolls without slipping down an incline that makes an angle of 22˚ with the horizontal. The disk starts from rest at a height of 42 cm above the horizontal. What is the linear speed of the disk when it reaches the horizontal? The moment of inertia of a disk about its center is $I_{disk} = (1/2)MR^2$, where M is the mass of the disk and R is the radius of the disk.

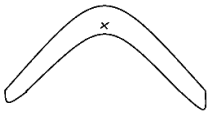
a. 1.76 m/s b. 2.34 m/s c. 2.87 m/s d. 3.83 m/s e. 4.06 m/s

12. A 2500 kg truck moving at a speed of 15 m/s plows into a parked car. The car has a mass of 1000 kg. The two vehicles lock bumpers and move away along the direction that the truck had been moving before the collision. What is the speed immediately after the collision?

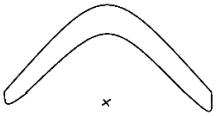
a. 6.0 m/s b. 9.5 m/s c. 10.7 m/s d. 12.7 m/s e. 21.0 m/s

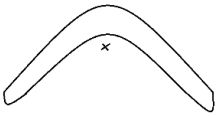
13. Consider the boomerang shown to the right: If this boomerang is made of wood that has uniform thickness and density, which "X" shows the approximate center of mass location?

a. 

b. 

c. 

d. 

e. 

14. A bicycle rider is traveling at 9.0 m/s on a flat road. The combined mass of bike and rider is 75 kg. The road must apply a forward force of magnitude 53 N to keep the bicycle moving at constant speed. At the speeds appropriate to this problem, the magnitude of drag force on the bicycle and rider is proportional to the square of the speed. What would the drag force be if the rider increased his speed to 12.1 m/s?

a. 39 N b. 53 N c. 71 N d. 96 N e. 170 N

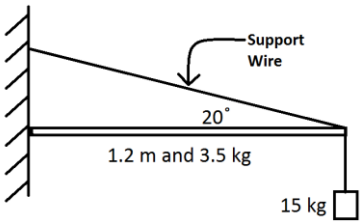
15. An elevator and its load have a total mass of 1000 kg. It rises a total of 6 floors, which is a total distance of 20.0 m in height. The elevator travels at a constant speed of 1.50 m/s. What is the power output necessary to accomplish this?

a. 13.3 kW b. 14.7 kW c. 30.0 kW d. 75.0 kW e. 196 kW

16. A 10.0 g bullet is fired horizontally from a gun with a muzzle velocity of 420.00 m/s. The gun is 1.50 m above the ground. Neglecting air resistance or other friction, calculate the magnitude of the velocity 0.50 seconds after leaving the barrel.

a. 315.00 m/s b. 415.10 m/s c. 420.03 m/s
d. 424.90 m/s e. 441.00 m/s

17. Consider the diagram to the right. This consists of a uniform board attached at the wall with a hinge and at the other end with a support wire. The board has a mass of 3.5 kg and is 1.2 m long. The angle the support wire makes with the board is 20˚. A 15 kg mass hangs from the end of the board. What is the tension in the support wire?

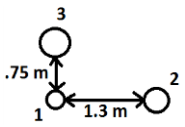


a. 170 N b. 180 N c. 430 N d. 480 N e. 530 N

18. A heavy crate is sliding across a rough floor. The crate begins with a velocity of 4.8 m/s and comes to rest after 4.7 m. What is the coefficient of friction between the floor and the crate?

a. 0.10 b. 0.23 c. 0.25 d. 0.50 e. 0.98

19. Three objects are placed at the positions shown. The mass of object 1 is 2.0 kg, the mass of object 2 is 4.0 kg, and the mass of object 3 is 5.0 kg. What is the magnitude of the net gravitational force on object 2 due to the other two masses (in units of N), where G is the Universal Gravitational Constant?

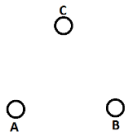


a. (8.89 kg^2/m^2) G b. (13.0 kg^2/m^2) G c. (13.2 kg^2/m^2) G
d. (13.6 kg^2/m^2) G e. (23.5 kg^2/m^2) G

20. An object of mass 0.275 kg moves along the x-axis under the influence of a single force given by: $\{-(283\,\mathrm{N/m})x+(85.6N)\}\hat{x}$, where x is the position of the object along the x-axis, and $\hat{x}$ is a unit vector in the positive x-direction. What is the acceleration of the object at x = 0.430 m?

a. -131 $\hat{x}$ m/s^2 b. 576 $\hat{x}$ m/s^2 c. -714 $\hat{x}$ m/s^2
d. 753 $\hat{x}$ m/s^2 e. 18.1 $\hat{x}$ km/s^2

21. Consider three charges located as shown in the figure. The magnitude and direction of the total electric force that charge A exerts on charge C is independent of

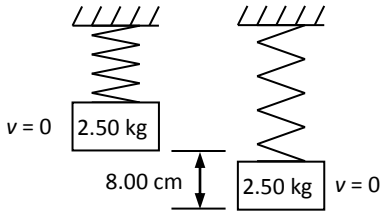


a. the sign of charge C.
b. the sign of charge A.
c. the position of charge B.
d. the distance between A and C.
e. the magnitude of the charge on C.

22. The triple point on a Pressure-Temperature diagram indicates

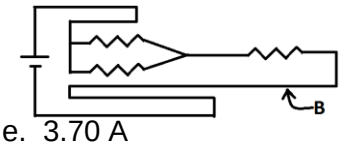
a. the curve for which liquid and gas can coexist.
b. the point at which adiabatic processes begin to dominate.
c. the point at the end of the curve for which liquid and gas can coexist.
d. the point at which isobaric and isothermal processes are identical.
e. the point at which liquid, solid, and gas can coexist in equilibrium.

23. In the left diagram, the spring shown is compressed 3.00 cm from its relaxed length. If the 2.50 kg mass attached to the spring is released from rest at the position in the left diagram, it drops 8.00 cm before momentarily coming to rest, as shown in the right diagram. What is the spring constant of the spring?



a. 6.13 N/cm b. 9.80 N/cm c. 24.5 N/cm d. 43.6 N/cm e. 147 N/cm

24. Three identical 6.00 ohm resistors are shown in the figure. The voltage that the battery produces is 7.40 volts. What is the current in the circuit at point B?

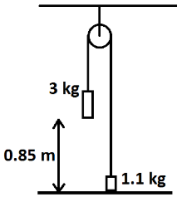


a. 0.41 A b. 0.82 A c. 1.22 A d. 2.43 A e. 3.70 A

25. A car (mass 850 kg) is waiting at an intersection for the light to change. Just as the light changes and the car starts moving, a bus (mass 2230 kg) comes by (in the same direction that the car will go) at a constant speed of 12.2 m/s. The car accelerates with a constant acceleration of 1.40 m/s^2. Assuming the bus maintains its constant speed and the car maintains its constant acceleration, what distance down the road will the car catch up to the bus?

a. 41.0 m b. 53.0 m c. 106 m d. 212 m e. 279 m

26. Two masses are attached via a massless string over a frictionless massless pulley as shown in the diagram. They are released from rest at time 0.00. How high above the floor will the 1.1 kg mass be at the peak of its trajectory? (The 1.1 kg mass does not strike the pulley.)

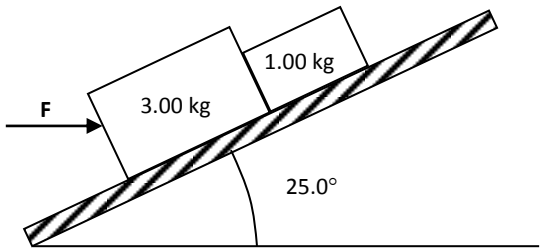


a. 0.00 m b. 0.62 m c. 0.85 m d. 1.24 m e. 3.49 m

27. For a hot reservoir at 473 K and a cold reservoir at 275 K, the maximum efficiency is attained with which type of engine cycle?

a. Carnot Cycle b. Otto Cycle c. Rankine Cycle
d. Diesel Engine Cycle e. Steam Engine Cycle

28. A 3.00 kg block and a 1.00 kg block on a frictionless surface which is inclined 25.0° 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. 20.3 N b. 27.1 N c. 39.2 N d. 43.5 N e. 103 N

29. The fundamental particles that make up a proton are

a. mesons. b. quarks. c. leptons. d. gravitons. e. photons.

30. A spherical mirror is used as a makeup mirror. If your face is placed 25.0 cm from the mirror you will see a virtual image that is magnified by a factor of 4.00. What is the focal length of the mirror?

a. 5.0 cm b. 8.3 cm c. 20.0 cm d. 33.3 cm e. 100 cm

31. Normal human speaking voice is typically about 65 dB in sound intensity level. A fire siren is designed to be easily heard from a long way away. If the siren is designed to produce sound at 116 dB with a frequency of 550. Hz at a distance of 1.00 m from the siren, what is the distance from the siren at which the sound intensity level of the siren will be the same as that of the conversation?

a. 164 m b. 178 m c. 355 m d. 982 m e. 12.6 km

32. A constant force is applied to an 1.0 kg object initially at rest at the origin. The force is $\mathbf{F} = 1.1\hat{\mathbf{x}} - 0.8\hat{\mathbf{y}}\ \mathrm{N}$. If no other forces act on this object, what is its position at time t = 3.0 s? (x and y components respectively in m)

a. 3.3 , -2.4 b. 0.9 , -0.9 c. 0.0 , 12.2 d. 12.2 , 0.0 e. 5.0 , -3.6

33. The dwarf planet Pluto has five moons. Styx is one of them and orbits in a circular orbit at a distance of 42,656 km from the center of Pluto. The mass of Styx is 2.60×10^{12} kg. The period of Styx' orbit around Pluto is 20.2 days. Ignoring the other four moons, what is the mass of Pluto?

a. 1.25×10^{15} kg b. 3.07×10^{16} kg c. 1.25×10^{18} kg
d. 1.51×10^{22} kg e. 1.13×10^{23} kg

34. A proton moving at a velocity of 300. km/s in the positive x direction, collides with an alpha particle in an elastic collision. The mass of the alpha particle is 6.644×10^{-27} kg and its velocity before the collision is 50.0 km/s in the positive y direction. If the proton exits the collision with a velocity of $(50.0\ \hat{\mathbf{x}} + 75.0\ \hat{\mathbf{y}})$ km/s what is the velocity of the alpha particle after the collision?

a. 2.54×10^4 m/s $\hat{\mathbf{x}} + 2.54 \times 10^4$ m/s $\hat{\mathbf{y}}$ b. 1.23×10^4 m/s $\hat{\mathbf{x}} + 3.38 \times 10^4$ m/s $\hat{\mathbf{y}}$
c. 3.50×10^4 m/s $\hat{\mathbf{x}} + 0$ m/s $\hat{\mathbf{y}}$ d. 3.01×10^4 m/s $\hat{\mathbf{x}} + 3.01 \times 10^4$ m/s $\hat{\mathbf{y}}$
e. 6.29×10^4 m/s $\hat{\mathbf{x}} + 3.11 \times 10^4$ m/s $\hat{\mathbf{y}}$

35. A 300. kg boat has an initial speed of 6.00 m/s as it passes under a bridge. At that instant a 90.0 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. 4.62 m/s b. 4.90 m/s c. 5.15 m/s d. 5.31 m/s e. 5.55 m/s