2018 Academic Challenge

PHYSICS TEST – SECTIONAL

– 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 (Sectional) – 2018

1. The Earth rotates on its axis once in 24.0 hours. The radius of the Earth is 6.38×10^6 m. The Earth orbits the sun at an average distance of 1.50×10^{11} m in 1.00 year. Based on this data what is the mass of the sun?

   a. 1.03×10^{22} kg
   b. 2.01×10^{30} kg
   c. 9.11×10^{31} kg
   d. 7.24×10^{33} kg
   e. 2.00×10^{45} kg

2. An object accelerates under the influence of a certain constant force. The acceleration is 6.27 m/s^2. If the object starts from rest at time t = 0.00 s, what distance does it move from time $t_1 = 1.31$ s to time $t_2 = 3.83$ s?

   a. 5.38 m
   b. 19.9 m
   c. 40.6 m
   d. 46.0 m
   e. 63.5 m

3. The engine of a go-cart causes the wheels to push backwards on the road so that the road pushes forwards with a force $\mathbf{F}_{Eng}$. If the total resistance force is $\mathbf{F}_{Res}$ and the net force is $\mathbf{F}_{Net}$, what is the acceleration of the go-cart if the total mass of the go-cart and driver is M?

   a. $\mathbf{F}_{Net}/M$
   b. $\mathbf{F}_{Res}/M$
   c. $\mathbf{F}_{Eng}/M$
   d. $(\mathbf{F}_{Net} - \mathbf{F}_{Res})/M$
   e. $(\mathbf{F}_{Net} - \mathbf{F}_{Eng})/M$

4. What is the sum of the following vectors? $\mathbf{A} = 1.36\,\hat{\mathbf{i}} - 2.10\,\hat{\mathbf{j}}$ and $\mathbf{B}$ = magnitude 1.49 with direction 224° counterclockwise from the +x axis.

   a. 3.15 at 84.7° counterclockwise from the +x axis
   b. 3.15 at 93.5° counterclockwise from the +x axis
   c. 3.15 at 275° counterclockwise from the +x axis
   d. 3.15 at 355° counterclockwise from the +x axis
   e. 3.97 at 52.3° counterclockwise from the +x axis

5. At a particular instant in time, a car on a level 37.5 m radius circular track has a speed of 15.0 m/s and is increasing in speed at 8.00 m/s^2. What is the magnitude of the car's acceleration at that moment?

   a. 0.00 m/s^2
   b. 6.00 m/s^2
   c. 8.00 m/s^2
   d. 10.00 m/s^2
   e. 14.00 m/s^2

6. While tuning a bicycle, it is inverted so the wheels spin more freely. For a particular bicycle, the moment of inertia of the wheel is 0.0176 kg$\cdot$m^2. A bicycle tuner notices that after she starts this wheel spinning at 3.00 rev/s it steadily slows because of friction. She measures that it takes 14.3 s to slow to 0.75 rev/s. What is the magnitude of the wheel's angular acceleration during this measurement?

   a. 1.10×10^{-2} rad/s^2
   b. 6.91×10^{-2} rad/s^2
   c. 0.157 rad/s^2
   d. 0.989 rad/s^2
   e. 56.6 rad/s^2

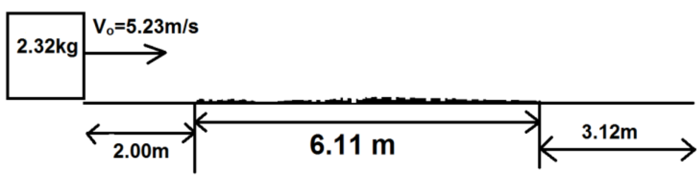
7. In the situation described in problem 6, what is the work done on the wheel by friction during the measurement?

   a. –2.93 J b. $-7.43\text{x}10^{-2}$ J c. 0.00 J
   d. $7.43\text{x}10^{-2}$ J e. 0.158 J

8. Consider a projectile fired from a height h above the ground with an initial velocity V_o at an angle θ below the horizontal. This projectile lands after a time t. What is the magnitude of the velocity at the instant when it lands on the ground?

   a. $V_o + \frac{h}{t}$
   b. gt
   c. $\sqrt{\left(gt - \frac{h}{t}\right)^2 + (V_o\cos\theta)^2}$
   d. $\sqrt{gh + \frac{1}{2}(V_o\sin\theta)^2}$
   e. $\sqrt{2gh + V_o{}^2}$

9. Consider a block of mass 2.32 kg with an initial velocity of 5.23 m/s as shown in the figure. This block travels 2.00 m on a flat frictionless surface and then encounters a 6.11 m length of rough surface with coefficient of kinetic friction 0.15. It then leaves that region and enters another frictionless surface that is 3.12 m long. What is the speed of the block at the end of the 3.12 m section?



   a. 2.38 m/s b. 3.06 m/s c. 4.24 m/s d. 5.05 m/s e. 5.23 m/s

10. An object follows a straight line path from point (1.00 m, 1.00 m) to the point (1.00 m, 4.00 m). It then is moved from the point (1.00 m, 4.00 m) to the point (5.00 m, 4.00 m) in a straight line. A force of **F** = 3*x***i**+*xy***j** acts on this object during the motion. What work is done by this force?

    a. 16.0 J b. 43.5 J c. 52.5 J d. 73.0 J e. 161 J

11. Consider a simple pendulum of mass 1.60 kg and length 1.78 m. An astronaut has this pendulum set up on the Moon. She measures the period of this pendulum to be 6.94 s. From the results of her experiment what does she predict the acceleration of gravity on the Moon to be?

    a. $3.70\text{x}10^{-2}$ m/s^2 b. 1.46 m/s^2 c. 1.63 m/s^2
    d. 2.17 m/s^2 e. 2.34 m/s^2

12. A car of mass 785 kg is moving with a velocity of 8.21 m/s in the same direction as a truck of mass 2410 kg and velocity 4.67 m/s. The car collides with the back of the truck and they lock bumpers so they are stuck together. What is the magnitude of their velocity immediately after the collision?

    a. 2.02 m/s b. 3.52 m/s c. 5.54 m/s d. 6.44 m/s e. 7.34 m/s

13. 3.00 moles of a monatomic ideal gas are sealed in a container at a temperature of 200 ˚C and an absolute pressure of 1.33 atm. If the volume of the gas remains constant, what will be the absolute pressure of the gas if the temperature increases to 500 ˚C?

    a. 0.814 atm b. 1.33 atm c. 2.17 atm d. 2.75 atm e. 3.33 atm

14. In the situation described in problem 13, what is the change in internal energy of the gas during this change in temperature?

    a. 1.20 kJ b. 3.74 kJ c. 7.48 kJ d. 9.95 kJ e. 11.2 kJ

15. Consider two long straight wires that are both parallel to the z axis. They intersect the xy plane at the points (0.00 cm, 0.00 cm) and (3.12 cm, 0.00 cm). The wire at the origin has a current of 768 mA flowing in the positive z direction and the other wire has a current of 768 mA flowing in the negative z direction. What is the magnetic field at the point (1.56 cm, 0.00cm) midway between the two points in the xy plane?

    a. 0.00 T
    b. $1.97x10^{-5}$ T in the positive y direction
    c. $1.97x10^{-5}$ T in the negative y direction
    d. $4.92x10^{-6}$ T in the positive y direction
    e. $4.92x10^{-6}$ T in the positive x direction

16. The event horizon in physics is most closely related to

    a. the parsec.
    b. the Hubble constant.
    c. quantum separability.
    d. the Higgs Boson.
    e. the Schwarzschild radius.

17. Alpha, beta, and gamma rays are considered ionizing radiation. Gamma rays consist of

    a. energetic Helium nuclei.
    b. energetic electrons.
    c. energetic neutrons.
    d. energetic photons.
    e. energetic quarks.

18. In a unit system in which velocity has units of duper and momentum has units of su, which response is a correct unit for mass?

    a. duper·su b. $duper·su^2$ c. $duper^2·su$ d. duper/su e. su/duper

19. An airplane travels at constant velocity in a direction 40.0° east of north. During a 1.00 hour interval, the plane's eastward coordinate changes by 200. miles. What is the change in the plane's northward coordinate during the same interval?

a. 169. miles b. 238. miles c. 256. miles d. 261. miles e. 311. miles

20. At its initial position, a 3.00 kg object is travelling East at a speed 4.00 m/s. What constant acceleration must it have to have a westward velocity of 8.00 m/s when it is 2.00 m West of its initial position?

a. 1.00 m/s^2 West
b. 2.00 m/s^2 West
c. 4.00 m/s^2 West
d. 8.00 m/s^2 West
e. 12.0 m/s^2 West

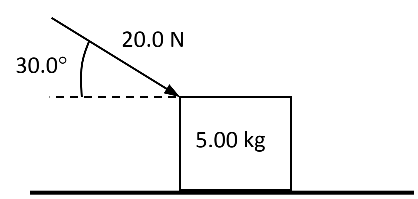
21. For the situation described in Problem 20, how much work is done on the object by a constant 20.0 N eastward force acting on the object during the motion from the initial position to the position 2.00 m West of the initial position?

a. –40.0 J b. –24.0 J c. 0.0 J d. 24.0 J e. 40.0 J

22. A projectile is launched at an angle θ above horizontal with an initial speed v. If θ remains fixed and v is varied, the range (horizontal distance travelled to return to same vertical position) is proportional to which function of v?

a. $1/v$ b. $1/\sqrt{v}$ c. $\sqrt{v}$ d. v e. v^2

23. As the 20.0 N force acts on the 5.00 kg block, the block slides along the level surface of the earth with an acceleration of 2.00 m/s^2 to the right. What is the coefficient of kinetic friction between the block and the level surface?

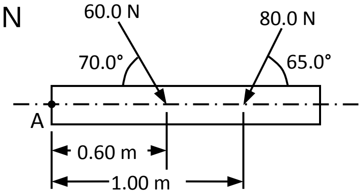


a. 0.124
b. 0.149
c. 0.204
d. 0.322
e. 0.567

24. In the situation described in Problem 23, what would be the magnitude of horizontally directed force additionally applied to the block that would result in constant velocity motion?

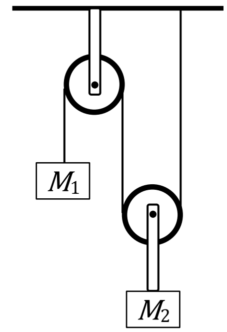
a. 8.66 N b. 10.0 N c. 15.0 N d. 17.3 N e. 20.0 N

25. On the massless rectangular bar in the diagram, what is the magnitude of the torque acting about point A as a result of the 60.0 N and 80.0 N forces acting on the bar?



a. 38.7 N·m
b. 46.1 N·m
c. 88.2 N·m
d. 106 N·m
e. 116 N·m

26. Masses M_1 and M_2 are suspended as shown in the diagram. If the pulleys and the ropes have negligible mass and friction, what is the magnitude of the acceleration of mass M_1?

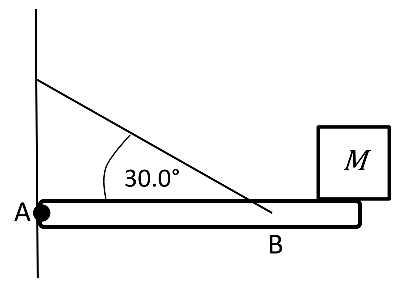


a. $\left|\frac{M_1-M_2}{M_1+M_2}\right| g$
b. $\left|\frac{2M_1-M_2}{2M_1+M_2}\right| g$
c. $\left|\frac{3M_1-M_2}{3M_1+2M_2}\right| g$
d. $\left|\frac{4M_1-2M_2}{4M_1+M_2}\right| g$
e. $\left|\frac{3M_1-2M_2}{3M_1+2M_2}\right| g$

27. In the situation described in Problem 26, assume $M_1 = M_2$. If the masses are held in place and released from rest, what will be the total kinetic energy of the two masses after the one that falls drops a distance d from its initial position?

a. $(M_1 + M_2)gd$ b. $(M_1 - M_2)gd$ c. $\left(M_1 + \frac{1}{2}M_2\right)gd$
d. $\left(M_1 - \frac{1}{2}M_2\right)gd$ e. $\left(\frac{1}{2}M_1 + M_2\right)gd$

28. The left end of a 10.0 kg horizontal uniform beam of length 1.00 L is attached to the vertical wall by a pin at point A. The beam is also supported by a 30.0° cable attached to the wall and to point B, which is a distance 0.700 L from the left end of the beam. The cable will break if the tension in the cable exceeds 400. N. What will be the maximum mass M placed at the end of the beam that this structure will support?



a. 5.66 kg
b. 9.29 kg
c. 12.2 kg
d. 14.3 kg
e. zero, the cable will break without any mass set on the end of the beam

29. A system is composed of two objects travelling toward each other which undergo a collision. During the collision no external forces act on the system. Which of the following statements is always true?

a. The total kinetic energy of the system is unchanged during the collision.
b. The total impulse acting on the system during the collision is zero.
c. The total mechanical energy of the system is unchanged during the collision.
d. The individual momentum of each object is unchanged during the collision.
e. All of the above statements are always true.

30. At temperature 20.0 °C, the rms speed of the monatomic atoms in an ideal gas is *v*. What will be the rms speed of the atoms in the gas if the temperature is increased to 80 °C?

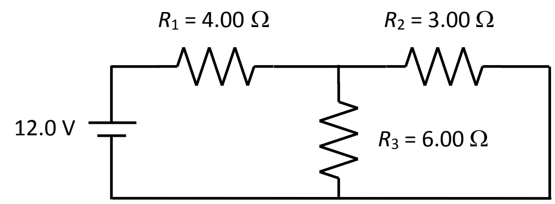
a. 1.10 *v* b. 1.20 *v* c. 2.00 *v* d. 4.00 *v* e. 16.0 *v*

31. An electron moves directly toward the right with constant velocity in a region with 2.00 T uniform magnetic field pointing into the page and a 300. V/m uniform electric field pointing toward the bottom of the page. What is the speed of the electron?

a. 0.667 cm/s b. 600 cm/s c. 150. m/s d. 600. m/s e. any speed

32. Determine the current that flows from the voltage source.

a. 1.00 A
b. 2.00 A
c. 3.00 A
d. 4.00 A
e. 6.00 A



33. A one-electron atom with atomic number *Z* has a ground state energy *E*. In the Bohr model of the atom, what would be the first excited state energy of a one-electron atom with atomic number 3*Z*?

a. 2*E*/3 b. 3*E*/4 c. 3*E*/2 d. 9*E*/4 e. 6*E*

34. The LHC (Large Hadron Collider) at CERN accelerates protons to an energy of 6.0 TeV (6.0×10^{12} eV). In the laboratory frame of reference, the CMS (Compact Muon Solenoid) detector is 21.6 m in length. What is the length of the CMS detector in the reference frame of the protons? The rest energy of a proton is 938 MeV.

a. 3.38 mm b. 27.0 cm c. 3.82 m d. 21.6 m e. 138 km

35. A radioactive source consisting of a single isotope has an initial activity 4.00 μCi. At a time 3.00 hours later, the activity of the source is 1.00 μCi. What is the mean lifetime of the isotope?

a. 1.00 hours b. 1.39 hours c. 1.50 hours d. 2.00 hours e. 2.16 hours