2017 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 ● , 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 ^{o}C = 273.15 K

WYSE – Academic Challenge
Physics Test (Regional) – 2017

1. The dimensionality of the classical spring constant, *k*, is:

   a. (mass*length)/time
   b. (mass*length^2)/time
   c. (mass*length)/time^2
   d. (mass*length^2)/time^2
   e. (mass)/time^2

2. A 6.00 kg object is dropped from rest. Just before it strikes the ground it has a velocity of 20.0 m/s. If friction can be ignored, from what height above the ground was it dropped?

   a. 1.02 m b. 3.33 m c. 10.2 m d. 20.4 m e. 40.8 m

3. Often associated with horses, a furlong is a unit of length equal to 201 m. The fortnight is a unit of time from Old English related to a job's pay period and equal to 14.0 days. What is a speed of 6.03 furlongs/fortnight as measured in cm/sec?

   a. 1.66x10^{-4} cm/sec b. 1.00x10^{-3} cm/sec c. 1.66x10^{-2} cm/sec
   d. 1.00x10^{-1} cm/sec e. 8.66x10^{3} cm/sec

4. A stone is thrown upward with a velocity of 4.00 m/s. It is released 0.820 m above the ground. What is its speed when it strikes the ground?

   a. 0.00 m/s b. 2.83 m/s c. 4.00 m/s d. 5.66 m/s e. 8.00 m/s

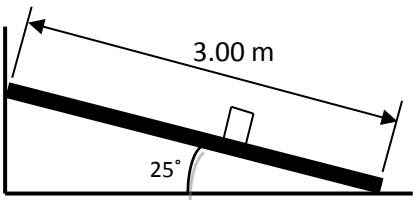
5. Vector **A** is given by **A**= 2.00 $\hat{\mathbf{x}}$ + 4.00 $\hat{\mathbf{y}}$ and vector **B** has a magnitude of 5.00 and is directed at an angle of 110˚ counterclockwise from the positive x axis. What is the vector **A** + **B** ?

   a. 7.00 $\hat{\mathbf{x}}$ + 9.00 $\hat{\mathbf{y}}$
   b. –3.00 $\hat{\mathbf{x}}$ + 4.00 $\hat{\mathbf{y}}$
   c. 3.71 $\hat{\mathbf{x}}$ + 8.70 $\hat{\mathbf{y}}$
   d. 8.70 magnitude at an angle of 30˚ from the positive x axis
   e. 0.290 $\hat{\mathbf{x}}$ + 8.70 $\hat{\mathbf{y}}$

6. The density of liquid nitrogen is 804 kg/m^3. The density of nitrogen gas (at STP) is 1.21 kg/m^3. If 33.3 ml of liquid nitrogen is converted (by heating) to nitrogen gas (at STP) and allowed to expand, what volume will it occupy?

   a. 2.21x10^{-2} m^3 b. 2.67x10^{-2} m^3 c. 5.01x10^{-2} m^3
   d. 2.66x10^{-3} m^3 e. 1.84x10^{-1} m^3

7. A 5.00 kg board that is 3.00 m long rests with one end on the floor and the other end leaning against a frictionless wall. The board makes a 25° angle with the horizontal floor. A 10.0 kg crate sits on the board at a point 2.00 m from the end that is touching the wall. What is the magnitude of the normal force at the wall acting on the board?



a. 147 N b. 123 N c. 81.4 N d. 57.2 N e. 15.0 N

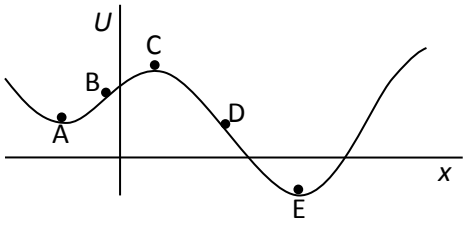
8. In the situation described in problem 7, the coefficient of static friction is such that the friction force barely keeps the board from moving on the floor. What is the coefficient of static friction between the board and the floor?

a. 0.389 b. 0.554 c. 0.834 d. 1.20 e. 2.57

9. A pendulum is pulled from its equilibrium position so that it makes an angle θ with the vertical. This raises it to a height of $l - l\cos\theta$ above its equilibrium position, where l is the length of the pendulum. On release, it swings without friction back toward its equilibrium position. When it reaches its equilibrium position, what is its speed?

a. $\sqrt{g(l - l\cos\theta)}$ b. $2g(l - l\cos\theta)$ c. $\sqrt{2gl\sin\theta}$
d. $\sqrt{2gl}$ e. $\sqrt{2g(l - l\cos\theta)}$

10. Consider the potential energy function shown in the figure. The points A, C, and E can be described respectively as:



a. stable, stable, and unstable equilibrium
b. unstable, neutral, and stable equilibrium
c. stable, unstable, and stable equilibrium
d. unstable, stable, and unstable equilibrium
e. neutral, unstable, and stable equilibruim

11. A car decelerates uniformly at a rate of 0.85 m/s^2 from an initial speed of 22.0 m/s. Find the speed of the car after 10 seconds.

a. 2.20 m/s b. 13.5 m/s c. 8.50 m/s d. 30.5 m/s e. 22.1 m/s

12. For the car in the previous problem find the total distance it travels before coming to a stop from its initial speed of 22.0 m/s.

a. 25.9 m b. 178 m c. 270 m d. 285 m e. 570 m

13. An 8.00 kg object is resting on 10.0˚ incline. The coefficient of static friction between the object and the incline is 0.400 and the coefficient of kinetic friction between the object and the incline is 0.300. What is the minimum magnitude of a force directed down the incline that is needed to initiate the object's motion?

a. 11.1 N b. 17.3 N c. 28.6 N d. 30.9 N e. 42.6 N

14. In the situation described in problem 13, a 50.0 N force directed down the incline is applied to the object. What will be the acceleration of the object down the plane?

a. 0.00 m/s^2 b. 3.35 m/s^2 c. 4.55 m/s^2 d. 5.06 m/s^2 e. 7.95 m/s^2

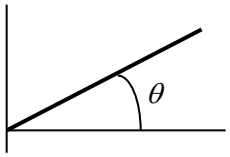
15. A tree is cut down in a logging operation. After trimming, it must be dragged out of the woods and then transported for processing. The effective coefficient of kinetic friction between the tree and the level ground is 0.63. The tractor will pull the 650 kg tree at a speed of 4.25 m/s. Find the minimum power needed by the tractor to accomplish this. (1hp = 746 W)

a. 2.33 hp b. 22.9 hp c. 26.2 hp d. 57.6 hp e. 17000 hp

16. A new temperature scale called the WYSEtemp (symbol WT) has been invented. In this temperature scale the freezing point of water is 15.0 WT and the boiling point of water is 245 WT. What is the measurement in WT of the boiling point of liquid nitrogen (which is −320 ˚F = −195.8 ˚C = 77.4 K)?

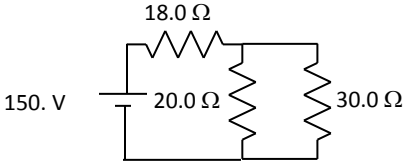
a. −240 WT b. −393 WT c. −435 WT d. −450 WT e. −465 WT

17. A uniform rod of length *L* and mass *m* is attached at one end so it can rotate in the vertical plane. It is initially held at rest at an angle θ above the horizontal, as shown. When released from rest, what is the angular acceleration of the rod? The moment of inertia of a uniform rod of length *L* and mass *m* about an end of the rod is $mL^2/3$.



a. $\frac{3g}{2L}\cos\theta$ b. $\frac{3g}{2L}\sin\theta$ c. $\frac{3g}{2L}$ d. $\frac{g}{2L}\sin\theta$ e. $\frac{g}{3L}\cos\theta$

18. How much power is supplied to the circuit by the voltage source?

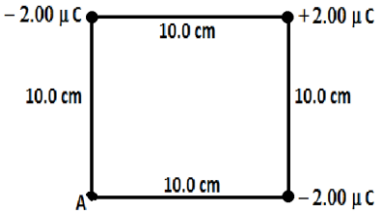


a. 150 W b. 276 W c. 450 W
d. 750 W e. 998 W

19. A 211 g mass on a frictionless table is attached to a spring with spring constant 1.65 N/m and unstretched length 21.1 cm. The other end of the spring is attached to a pivot. The mass is set moving in uniform circular motion with a speed 78.5 cm/s. What is the radius of the circles that are made?

a. 19.4 cm b. 28.1 cm c. 40.5 cm d. 61.6 cm e. 877 cm

20. Consider the charge distribution shown. Find the electric potential at point A.



a. −232 kV b. −2700 kV c. +2320 kV
d. −1640 kV e. 7.19 kV

21. A 10.0 kg object is pulled along a horizontal surface. The coefficient of kinetic friction between the object and the surface is μ_k = 0.18. The pulling force has a magnitude of 150 N and is applied at an angle of 25° above the horizontal. How much work does the pulling force do in moving the object 7.00 m?

a. 171 J b. 189 J c. 828 J d. 952 J e. 1050 J

22. What is the torque if the radius vector is $(3\,\hat{\mathbf{x}} + 2\,\hat{\mathbf{y}})$ m and the force vector is $(-5\,\hat{\mathbf{x}} + 7\,\hat{\mathbf{y}})$ N?

a. −1 N·m b. $7\,\hat{\mathbf{z}}$ N·m c. $11\,\hat{\mathbf{z}}$ N·m d. 29 N·m e. $31\,\hat{\mathbf{z}}$ N·m

23. A 12.0 kg mass is located at the position $(2\,\hat{\mathbf{x}} + 5\hat{\mathbf{y}})$ m. A 7.00 kg mass is located at the position $(4\,\hat{\mathbf{x}} + 1\,\hat{\mathbf{y}})$ m. What is the position of the center of mass of this system?

a. $(2.74\,\hat{\mathbf{x}} + 3.53\,\hat{\mathbf{y}})$ m b. $(3\,\hat{\mathbf{x}} + 3\,\hat{\mathbf{y}})$ m c. $(3.17\,\hat{\mathbf{x}} + 2.33\,\hat{\mathbf{y}})$ m
d. $(4.42\,\hat{\mathbf{x}} + 1.89\,\hat{\mathbf{y}})$ m e. $(3.26\,\hat{\mathbf{x}} + 2.47\,\hat{\mathbf{y}})$ m

24. Two putty balls move along a frictionless horizontal surface. The mass of the first is 45.0 g and it is moving in the +y direction with a speed of 2.10 m/s. The mass of the second is 62.0 g and it is moving in the +x direction with a speed of 1.60 m/s. The two balls collide at the origin and the collision is perfectly inelastic. What is the speed of the first ball after the collision?

a. 1.28 m/s b. 1.52 m/s c. 1.81 m/s d. 2.20 m/s e. 3.70 m/s

25. A 65.0 kg woman is riding on a 29.0 kg cart which is traveling without resistance at a speed of 3.40 m/s along a horizontal section of road. If she jumps off the cart such that the horizontal component of her velocity before she lands is 0.00 with respect to the Earth, what is the change in speed of the cart?

a. 7.62 m/s b. 0.00 m/s c. 6.12 m/s d. 2.72 m/s e. 11.0 m/s

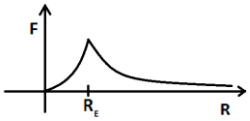
26. A 750 kg car on a level highway initially traveling at 19.6 m/s hits the brakes. What magnitude retarding force is required to stop this car in a distance of 45.0 m?

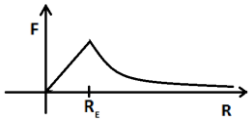
a. 327 N b. 3200 N c. 3680 N d. 7350 N e. 14700 N

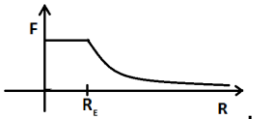
27. In the situation described in problem 26, according to Newton's Laws, what is primarily applying this force to the car to stop it?

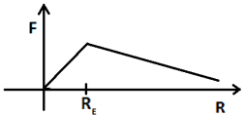
a. the wind
b. the road
c. the wheels
d. the brake pads
e. none of the above

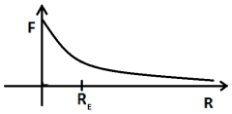
28. A graph of force of gravity as a function of radius from the center of the Earth looks like:

a. 

b. 

c. 

d. 

e. 

29. A baseball batter hits a ball with a velocity of 41.3 m/s at an angle of 28˚ above the horizontal from a point over home plate at a height of 0.920 m above the plate. The ball heads toward the outfield wall 142 m from home plate. The wall is 2.50 m high at that point. If nobody touches the ball it

a. does not even get out of the infield (distance 47.3 m).
b. first strikes the ground in the outfield.
c. strikes the wall before hitting the ground.
d. falls just outside the wall, clearing the top of the wall by a few centimeters.
e. falls well outside of the wall, clearing the top of the wall by several meters.

30. An object 2.58 cm tall is placed 41.3 cm from a concave mirror with a radius of curvature of 96.8 cm. Find the height of the image.

a. 0.355 cm b. 1.74 cm c. 4.50 cm d. 6.82 cm e. 17.6 cm

31. A 65.0 cm long stainless steel rod is dropped to the floor so that one end hits first. A microphone detects the initial vibrations in the rod as a 4.45 kHz tone. The rod vibrates at its fundamental as an object "open" at both ends. What is the speed of sound in the rod?

a. 2890 m/s b. 3620 m/s c. 3860 m/s d. 5790 m/s e. 8680 m/s

32. A 200. kg (including spacesuit) astronaut is separated 20.0 m from the spaceship (in space)! The astronaut is at rest relative to the spaceship. The astronaut has a tool (not included in the mass of the astronaut) with a mass of 6.00 kg. In order to get back to the spaceship, the astronaut throws the tool so that it moves away from the ship at a velocity of 5.50 m/s. How long does it take before this maneuver gets the astronaut back to the spaceship?

a. 3.64 s b. 110 s c. 121 s d. 125 s e. 183 s

33. Given that Io, one of the moons of Jupiter, has an orbital period of 1.77 days and orbits at an average radius of 422000 km, calculate the mass of Jupiter.

a. 1.18×10^{3} kg b. 1.98×10^{21} kg c. 6.05×10^{26} kg
d. 1.90×10^{27} kg e. 2.51×10^{28} kg

34. Work function in physics is related to which of the following?

a. when the total energy of an atom is zero so that the electron is no longer bound to the nucleus and the atom has been ionized
b. the minimum amount of work it takes to liberate an electron from a metal
c. when two particles are held together by an attractive force, work must be done by an external agent to separate them
d. the work required to raise the temperature of one mole of a substance by one degree Celsius
e. the net mechanical work done in changing kinetic energy and is written as $W_{net} = \Delta KE$

35. A sphere of radius 0.250 m, surface temperature 29.0˚C, and emissivity 0.780 is suspended inside a large oven whose inside walls are at a temperature of 129˚C. What is the net rate of radiative energy transfer to the sphere? The Stefan-Boltzmann constant is $\sigma = 5.67 \times 10^{-8}$ W/(m^2·K^4).

a. 3.47 W b. 2.40 W c. 909 W d. 619 W e. 9.59 W