2014 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)
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)
Stefan-Boltzmann constant	σ	5.6704×10^{-8} W/(m^2·K^4)

Other information:

Acceleration due to gravity at earth's surface: g = 9.80 m/s^2

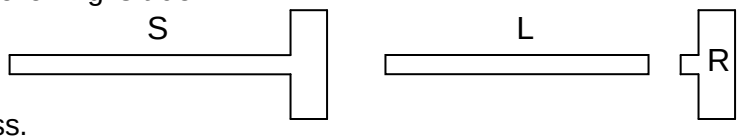
0.00 ^{o}C = 273.15 K

WYSE – Academic Challenge
Physics Test (Regional) – 2014

1. For a particle, the time rate of change of its linear momentum is equal to

   a. the net impulse acting on the particle.
   b. the net force acting on the particle.
   c. the work done on the particle.
   d. the time rate at which work is done on the particle.
   e. none of the above.

2. A wooden board of uniform thickness and density is cut into the shape (S) shown below. Piece S is then cut at its center of mass to produce a right piece (R) and a left, rectangular shaped piece (L). Which of the following is true.

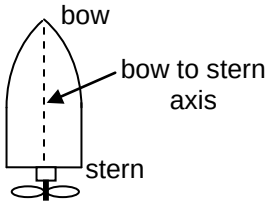


   a. L must have greater mass.
   b. R must have greater mass.
   c. L and R must have equal mass.
   d. L and R must have equal surface areas.
   e. Both c and d are true.

3. A small rock is released from rest from the top of a tall vertical cliff and falls freely. The rock falls a distance of 19.6 m after 2.00 s have elapsed. How much farther does the rock drop in the next 1.00 s?

   a. 4.90 m b. 44.1 m c. 24.5 m d. 9.80 m e. 49.0 m

4. A motor boat crosses a river with its bow to stern axis perpendicular to the river flow. The boat travels at a constant speed of 12.0 km/hr as seen by an observer standing on one of the banks of the river. If the water flows at a speed of 5.00 km/hr relative to the same observer, what is the speed of the boat relative to the water?



   a. 4.12 km/hr b. 13.0 km/hr c. 7.00 km/hr d. 17.0 km/hr e. 10.9 km/hr

5. A 12.0 kg mass makes a head-on collision with a 22.0 kg mass that is initially at rest. As a result of the collision, the 22.0 kg mass acquires a speed of 15.0 m/s, and the 12.0 kg mass rebounds in the direction opposite to its initial velocity, with a speed of 4.00 m/s. The initial speed of the 12.0 kg mass, prior to the collision, was:

   a. 23.5 m/s. b. 31.5 m/s. c. 20.7 m/s. d. 19.9 m/s. e. 11.0 m/s.

6. For the situation in problem 5, if the contact time between the 12.0 kg mass and the 22.0 kg mass is 0.280 s, what is the magnitude of the average force acting on the 22.0 kg mass due to contact with the 12.0 kg mass?

   a. 171 N b. 117 N c. 92.4 N d. 1180 N e. 1490 N

7. If "$\mathbf{F}_i$" denotes the ith force acting on an object, and *m* is the mass of the object, which of the following is a statement of Newton's first law of motion? (Assume all observations of the object are made from an inertial frame of reference.)

   a. If $\sum_i \mathbf{F}_i = 0$, then the speed of the object will decrease with time.

   b. If $\sum_i \mathbf{F}_i = 0$, then the velocity of the object must be 0.

   c. If $\sum_i \mathbf{F}_i = 0$, then the velocity of the object must be constant.

   d. The acceleration of an object is given by $\left(\sum_i \mathbf{F}_i\right)/m$.

   e. None of the above.

8. As a certain basketball travels from one bounce to another above a horizontal floor, the *x* and *y* components of displacement of its center of mass are given by:

   $x = 0 + (13.2\ \text{m/s})\cos(26.5^\circ)t$ and

   $y = 0.119\ \text{m} + (13.2\ \text{m/s})\sin(26.5^\circ)t - \frac{1}{2}(9.80\ \text{m/s}^2)t^2$,

   where *t* is the time in seconds from the first bounce.
   What is the speed of the ball at the top most point of its path?

   a. 0.00 m/s b. 11.8 m/s c. 5.89 m/s d. 4.21 m/s e. 13.2 m/s

9. For the motion described in problem 8, what is the time between bounces?

   a. 0.00 s b. 1.10 s c. 1.22 s d. 1.20 s e. 1.64 s

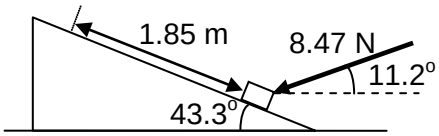
10. During a certain trip, a car travels a total distance of 126 km. The speed of the car is 32.0 km/hr for one part of the trip, and 68.0 km/hr for the remainder of the trip. If it takes 3.00 hours to make the entire trip, the average speed during the trip is:

    a. 58.0 km/hr.
    b. 42.0 km/hr.
    c. 50.0 km/hr.
    d. not determinable from the given information.
    e. none of the above.

11. Which scientist first devised and did experiments involving an apparatus which used charged oil droplets to determine the elementary charge of an electron?

    a. Andre-Marie Ampère
    b. Félix Savart
    c. James Maxwell
    d. Charles Coulomb
    e. Robert Millikan

12. A small block of mass 0.510 kg is pushed up a frictionless incline by a force of magnitude 8.47 N acting at an angle of 11.2° below the horizontal. After the block has been pushed a distance of 1.85 m along the 43.3° incline, how much work has been done by the given force?



a. 9.10 J b. 15.7 J c. 13.3 J d. 15.4 J e. 11.4 J

13. In problem 12, how much does the gravitational potential energy of the mass change as it moves 1.85 m along the incline? (Assume the incline is on the Earth.)

a. 9.25 J b. 0.944 J c. 6.73 J d. 6.34 J e. Same answer as 12.

14. Again using the situation in problem 12, what is the magnitude of the net force acting on the mass?

a. 1.49 N b. 10.5 N c. 13.5 N d. 10.6 N e. 3.26 N

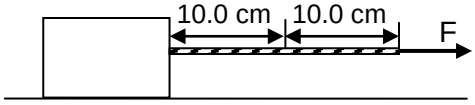
15. Assuming that a basketball is in free flight, when it is at the top of its parabolic trajectory, the basketball:

a. has a downward acceleration and a downward velocity.
b. has a horizontal velocity, but no acceleration.
c. has no acceleration, but has both downward and horizontal components of velocity.
d. has a downward acceleration and both horizontal and downward components of velocity.
e. has a downward acceleration and a horizontal velocity.

16. An electric cart has a battery capable of delivering 240. W·h of energy. The cart and a single occupant/driver have a combined weight of 950. N. Starting with fully charged battery, the cart is driven up a steady incline at a slow, constant speed. If the cart eventually achieves an elevation gain of 368 m before depleting the electrical energy in the battery, what percentage of the battery's initial energy was lost to frictional forces and the like?

a. 59.5%
b. 95.9%
c. 14.9%
d. 40.5%
e. Cannot be determined since the cart will never reach an elevation gain of 368 m.

17. A rigid box, having a mass of 75.0 g, is attached to a uniform rope, which has a total mass of 18.0 g. The system is being pulled by a force, **F**, as shown. If friction between box and the horizontal floor is negligible, and the rope does not sag appreciably, what is the tension in the rope at its midpoint, 10.0 cm from each end?

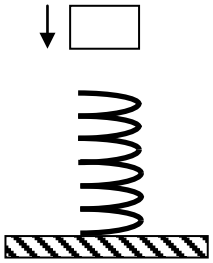


a. 0.00 b. 1.00 F c. 0.903 F d. 0.806 F e. 0.500 F

18. A 28.9 g bullet, which has a muzzle exit speed of 400. m/s, is fired straight downward from a vertical cliff and travels a distance of 389 m before coming to rest inside a thick block of wood. (Note that the 389 m includes the distance traveled inside the wood.) Ignoring air friction, if the bullet travels 23.7 cm inside the block of wood before coming to rest, what is the magnitude of the average force that the wood exerts on the bullet?

a. 4.65 kN b. 9.76 kN c. 10.2 kN d. 9.29 kN e. 102 kN

19. A 0.248 kg block is dropped onto a vertically oriented, massless spring, which has a spring constant equal to 125 N/m. When the block makes contact with the spring, it becomes attached to it, and continues to compress the spring by 0.150 m before momentarily stopping. From initial contact to maximum compression of the spring, what is the combined work done on the block by the spring force and the gravitational force acting on the block?



a. -2.45 J b. -1.04 J c. 1.77 J d. 3.18 J e. 0.00 J

20. An automobile, having a **weight** of 1.57×10^4 N, accelerates uniformly, and without slipping, from rest to 16.0 m/s in 7.20 seconds while traveling along a horizontal stretch of road. Ignoring air friction, what average power was delivered to the wheels during this period of time?

a. 251 kW b. 28.5 kW c. 279 kW d. 57.0 kW e. 558 kW

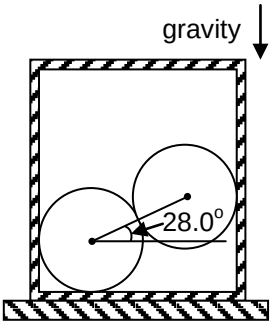
21. A point object of mass 2.00 *M* is located on the y-axis at y = 4.00 cm. A second point object of mass 1.00 *M* is located on the x-axis at x = 3.00 cm. What is the distance from the origin to the center of mass of this two mass system?

a. 3.67 cm b. 1.67 cm c. 5.00 cm d. 8.11 cm e. 2.85 cm

22. To simulate the high accelerations experienced by astronauts during liftoff, astronaut trainees are put into a large centrifuge. If the trainee is to experience a centripetal acceleration of 12.0 times the acceleration due to gravity at the Earth's surface, how many **revolutions** must the centrifuge rotate each **second** if the trainee is 18.0 m from the axis of rotation?

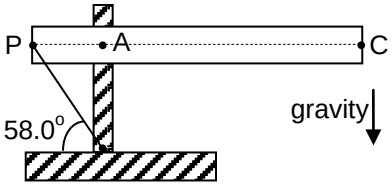
a. 0.816 b. 1.04 c. 6.53 d. 0.407 e. 2.56

23. Two identical, uniform, frictionless cylinders, each having weight *W*, are resting in static equilibrium inside a box, as shown. What magnitude of force does the left wall of the box exert on the left cylinder?



a. 0.883 *W*
b. 1.532 *W*
c. 0.469 *W*
d. 1.88 *W*
e. 0.532 *W*

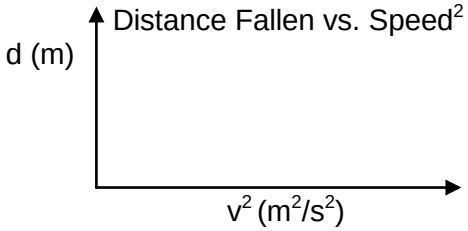
24. A uniform, horizontal plank, having a weight of 254 N, is held in static equilibrium by a frictionless pin at A and a cord tied at the plank's left end. The length of segment PA is 20.0 cm, and the length of AC is 70.0 cm. What is the tension in the cord?



a. 1050 N b. 444 N c. 524 N d. 318 N e. 374 N

25. An object is dropped from rest. If a graph of the distance the object has fallen, d, versus the square of the objects speed, v^2 , is made as shown, what is the expected slope of the resulting line, if air friction can be ignored? In the responses, u represents the correct SI units of the slope.

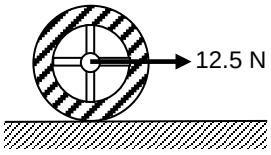
a. 5.10×10^{-2} u
b. 19.6 u
c. 9.80 u
d. 1.02×10^{-1} u
e. The result will be a parabola, and thus the slope is not constant.



26. A wheel, initially rotating at a rate of -12.0 rad/s, rotates with constant angular acceleration, and reaches an angular speed of +15.0 rad/s, 5.75 s later. What is the angular acceleration of the wheel during this time interval?

a. 3.00 rad/s^2 b. 0.522 rad/s^2 c. 4.70 rad/s^2 d. 2.35 rad/s^2 e. 0.261 rad/s^2

27. A constant, horizontal force of 12.5 N acts upon a wheel of mass 16.0 kg and diameter 0.667 m, causing it to accelerate on a horizontal surface, without slipping, at a rate of 0.369 m/s^2. What is the magnitude of frictional force acting on the wheel?



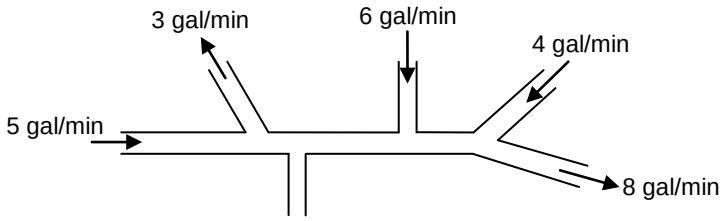
a. 6.60 N b. 18.4 N c. 5.90 N d. 0.781 N e. 4.61 N

28. For the same situation described in problem 27, what is the angular acceleration of the wheel?

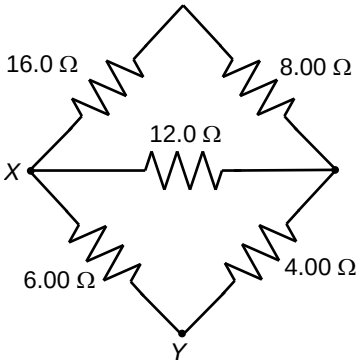
a. 1.11 rad/s b. 0.123 rad/s c. 0.553 rad/s d. 0.246 rad/s e. 0.408 rad/s

29. Assuming the pipes shown below are filled with an incompressible fluid, what is the flow rate and direction in the unlabeled pipe?

a. 3 gal/min in
b. 4 gal/min in
c. 5 gal/min out
d. 4 gal/min out
e. 2 gal/min out



30. If a 9.00 V battery with negligible internal resistance were connected between points X and Y, (and thus in parallel with the 6.00 Ω resistor), how much current would flow through the battery?

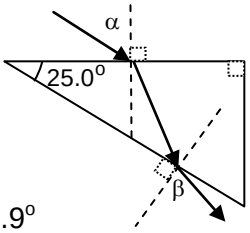


a. 0.196 A
b. 1.73 A
c. 1.01 A
d. 2.03 A
e. 2.25 A

31. A certain empty can has a total volume (including wall and bottom thickness) of 1260 cm^3 and a mass of 152 g. Lead shot is added to the can until the can floats in water with 75.0% of the can's volume submerged. If the density of lead is 11.4 g/cm^3, and that of water is 1.00 g/cm^3, how many grams of lead were added to the can?

a. 69.6 g b. 11.1×10^2 g c. 945 g d. 97.2 g e. 793 g

32. A ray of light travels from air into a transparent triangular prism along the path shown in the diagram. If the index of refraction of the prism is 1.32, and the value of α is 20.0°, what will be the value of β at the other prism surface shown?



a. 75.0° b. 58.1° c. 140.° d. 40.0° e. 31.9°

33. 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?

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

34. If a particle with a net charge equivalent to two electrons makes 6.00 rev in a magnetic field of 164.0 mT in a time of 23.4 ms, what is the particle's mass?

a. 1.29×10^{-21} kg
b. 7.38×10^{-21} kg
c. 2.05×10^{-22} kg
d. 3.26×10^{-23} kg
e. 1.96×10^{-22} kg

35. A concave mirror has a radius of curvature equal to 48.0 cm. If it is positioned such that the upright image of a woman's eye is 2.80 times the size of her actual eye, how far is her actual eye from the mirror?

a. 32.6 cm b. 15.4 cm c. 30.9 cm d. 65.1 cm e. 7.71 cm