2016 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. 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} $C^2/(N \cdot m^2)$
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)

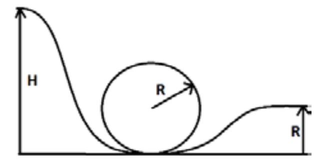
Other information:

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) – 2016

1. A frictionless roller coaster has a loop-the-loop section as shown. The beginning point is at height *H* and the ending point is at the same height as the center of the loop-the-loop, *R*. If a car starts from rest at the beginning point what is the speed of the car at the end point?

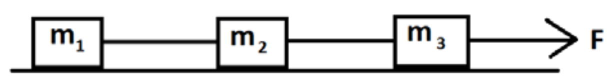


a. $\sqrt{2g(H-R)}$ b. $\sqrt{g(H-R)}$ c. $\sqrt{2g\frac{(H-R)^2}{R}}$ d. $\sqrt{2g\frac{R^2}{(H-R)}}$ e. $\sqrt{2gH}$

2. Atmospheric pressure at the Earth's surface is about 1.01×10^5 Pa. What is the pressure 12 m below the surface of a lake on Earth, assuming that the density of lake water is 1.00×10^3 kg/m^3?

a. 0.12 atm b. 1.12 atm c. 1.16 atm d. 2.16 atm e. 8.42 atm

3. Consider three masses connected together by light string as shown. The masses are m_1 = 0.54 kg, m_2 = 0.79 kg and m_3 is unknown. The force, **F**, applied horizontally to a string attached to mass m_3, as shown, has a magnitude of 11 N. This force causes an acceleration of 4.8 m/s^2 of mass m_2 in the direction of the force. What is the mass m_3?



a. 0.58 kg b. 0.96 kg c. 2.3 kg d. 2.9 kg e. 4.2 kg

4. A dentist's drill starts at rest and rotates through 5000 radians in getting up to speed. The final speed of the drill is 1000 revolutions per second. The angular acceleration is constant during that time. What is the time it takes to get to that operating speed?

a. 0.2 s b. 0.8 s c. 1.3 s d. 1.6 s e. 5 s

5. A spring of spring constant k = 211 N/m is compressed 43.8 cm from equilibrium by a mass m = 18.2 kg, as shown in the diagram. The area near the spring is frictionless. There is a rough surface beyond the spring with coefficient of kinetic friction 0.024. What is the potential energy of the system due to the compression of the spring?

a. 1.75 J b. 5.08 J c. 20.2 J d. 78.1 J e. 92.4 J

6. In the situation described in problem 5, what distance will the mass move across the rough surface before coming to rest?

a. 0.113 m b. 0.409 m c. 0.518 m d. 4.73 m e. 18.3 m

7. A car is traveling on a slippery banked curved road. The radius of the circular curve is 85.0 m and the angle of the bank in the curve is 15.0˚. The mass of the car is 740. kg. The road is frictionless. The car has a velocity so that it maintains its position in the road lane as it navigates the curve. What is the magnitude of the normal force of the road acting on the car?

a. 1880 N b. 1940 N c. 6420 N d. 7250 N e. 7510 N

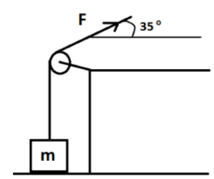
8. The ascent phase of the moon landing for Apollo 17 had a vehicle with total mass of 4700 kg. The thrust that the engines produced was 16000 N. The speed of the ejected fuel during the ascent was 3050 m/s relative to the vehicle. What was the initial rate of fuel consumption in the ascent phase?

a. 0.65 kg/s b. 0.90 kg/s c. 1.5 kg/s d. 3.4 kg/s e. 5.2 kg/s

9. Momentum is conserved in collisions. Which of these statements is also true about collisions?

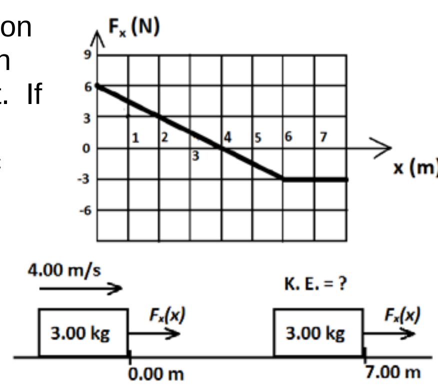
a. In inelastic collisions, momentum is not conserved.
b. In inelastic collisions, mechanical energy is conserved.
c. In elastic collisions, mechanical energy is conserved.
d. In elastic collisions, momentum is not conserved.
e. In elastic collisions, impulse is energetically favored.

10. Consider the mass m = 1.75 kg, shown in the figure. A light rope passes over a pulley and is pulled with a force **F** at the 35° angle shown. The mass accelerates upward with an acceleration of 2.40 m/s^2. What is the magnitude of the force **F**?



a. 13.0 N b. 17.5 N c. 21.4 N d. 26.1 N e. 37.2 N

11. As a 3.00 kg object moves along the x-axis, it is acted upon by a single force that acts along the x-axis and varies with the object's position, as indicated in the graph to the right. If the velocity of the object is 4.00 m/s in the positive x-direction when the object is at 0.00 m, what will its kinetic energy be when it is at x = 7.00 m?

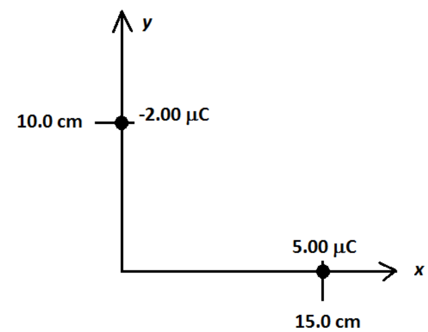


a. 12.0 J
b. 18.0 J
c. 24.0 J
d. 30.0 J
e. 36.0 J

12. A three car train with each car having a mass of 12700 kg is rolling along the tracks at a speed of 1.79 m/s. The train will couple with an empty set of four connected stationary cars initially at rest with mass 4290 kg each. What is the speed of the seven car train immediately after the collision?

a. 0.61 m/s b. 1.23 m/s c. 1.34 m/s d. 1.49 m/s e. 2.47 m/s

13. A 5.00 μC charge is located at a position x = 15.0 cm, y = 0.00 cm. A −2.00 μC charge is located at the position x = 0.00, y = 10.0 cm. What is the magnitude of the electric field at the origin?



a. 0.20×10^6 N/C
b. 1.80×10^6 N/C
c. 2.00×10^6 N/C
d. 2.69×10^6 N/C
e. 3.79×10^6 N/C

14. Consider a cubic block of ice 0.500 m on a side. The density of ice is 917 kg/m^3. This block is dropped into the Dead Sea. The salt water of the Dead Sea has a density of 1240 kg/m^3. What percentage of the ice block will be above the water (assuming that the salt water is calm and the measurement is taken before any of the ice is able to melt)? (The density of fresh water is 1000 kg/m^3.)

a. 8.3% b. 9.1% c. 26.0% d. 35.2% e. 74.0%

15. The Earth is surrounded by an electric field of magnitude 130. N/C pointed radially inward. If we assume that the Earth is a sphere of radius 6.37×10^6 m with a spherically symmetric charge distribution, what is the total electric charge on the Earth?

a. -4.67×10^4 C b. 6.23×10^4 C c. -5.87×10^5 C
d. 7.38×10^6 C e. -8.28×10^9 C

16. Consider a yo-yo released from rest with the string held stationary at the top. The mass of the yo-yo is 0.061 kg and the moment of inertia of the yo-yo is 4.1×10^{-5} kg m^2. The radius of the spindle that the string unrolls from is 0.52 cm. What is the linear speed of the yo-yo after it has unrolled (and changed height) a total of 85 cm? Neglect the mass and size of the string.

a. 0.67 m/s b. 0.80 m/s c. 0.82 m/s d. 0.98 m/s e. 4.1 m/s

17. Consider the human eye to be 1.70 cm in diameter. What power must the lens system of this eye have to clearly focus on an object 55.0 cm away?

a. 1.65×10^{-2} D b. 1.65 D c. 57.0 D d. 58.8 D e. 60.6 D

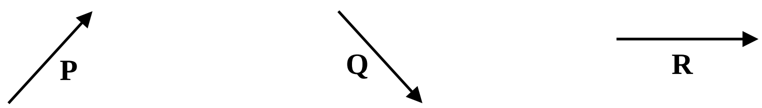
18. The magnitude of a force on an object, F, is proportional to the ratio of the object's speed, v, and its cross-sectional area, A:

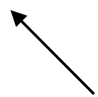
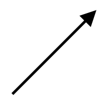
$$F = C\frac{v}{A}$$

What are the dimensions of the constant C ?

a. $[M][L]^2[T]^{-1}$ b. $[M][L][T]^{-2}$ c. $[M][L]^2[T]$ d. $[M]^2[L][T]^{-2}$ e. $[M][L]^3[T]^{-2}$

19. Given vectors **P**, **Q**, and **R** below, which response is the best estimate of **P** + **Q** – **R**?



a.  b.  c.  d.  e. 

20. An object travels from a point A to a different point B. The magnitude of the average velocity for the trip is equal to the average speed for the trip. Which statement is necessarily true about the motion?

a. The velocity during the motion was constant.
b. The acceleration during the motion was zero.
c. The acceleration during the motion was constant.
d. The speed during the motion was constant.
e. The direction of the velocity during the motion was constant.

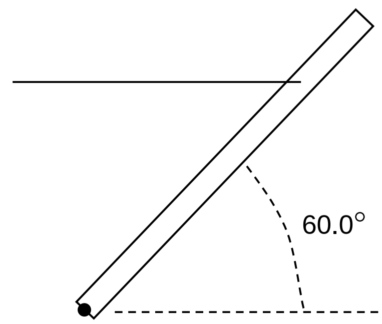
21. A 3.00 kg mass object has an initial speed 4.00 m/s. After 24.0 J of work are done on the object, what is the final speed of the object?

a. 0.00 m/s b. 2.83 m/s c. 5.66 m/s d. 6.25 m/s e. 8.00 m/s

22. At a particular instant in time, a car on a level 50.0 m radius circular track has a speed 20.0 m/s and is increasing in speed at 6.00 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. 10.0 m/s^2 e. 26.0 m/s^2

23. A uniform density board has weight 200. N and length 3.00 m. It is pinned at its lower left end and a horizontal string tied 0.600 m from the upper end of the board prevents the board from falling from the position shown. What is the tension in the string?

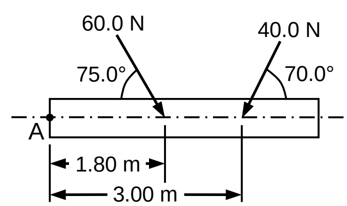


a. 38.9 N
b. 72.2 N
c. 84.6 N
d. 125. N
e. 216.5 N

24. A figure skater spins at a high rate of rotation with arms pulled in tight to the body. The skater then stretches the arms out away from the body, lowering the rate of rotation. What is the correct explanation for this change in rate of rotation?

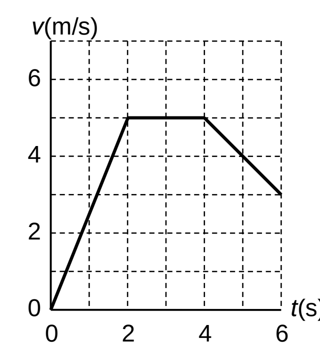
a. Moving the arms away from the body increase the air drag, creating a torque that slows down the rate of rotation.
b. The rotation is independent of the position of the arms. The skater only slows because of the force of the ice on the skates.
c. The theory of special relativity applied to the relative velocity of the arms, the skater's body, and the observer, results in more time dilation because the skater's arms move faster.
d. Moving the arms away from the body increases the gravitational potential energy. Conservation of energy thus requires a lower rate of rotation to decrease kinetic energy.
e. Moving the arm's away from the body increases the moment of inertia of the skater. Conservation of angular momentum thus requires slower rotation.

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 40.0 N forces acting on the bar?



a. 38.7 N·m b. 69.0 N·m c. 168. N·m
d. 186. N·m e. 217. N·m

26. The velocity of an object in rectilinear motion as a function of time is shown on the graph. What is the displacement of the object during the interval from 0.0 s to 6.0 s?

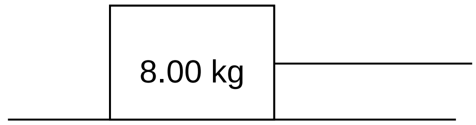


a. 3.0 m
b. 6.0 m
c. 16. m
d. 23. m
e. 27. m

27. For the motion described in problem 26, what is the magnitude of the average acceleration of the object between 0.0 s and 6.0 s?

a. 0.0 m/s^2 b. 0.22 m/s^2 c. 0.50 m/s^2 d. 1.5 m/s^2 e. 3.5 m/s^2

28. An 8.00 kg object is dragged across a level surface with a horizontal rope, as shown. The surface applies a 12.0 N friction force to the object. If the object increases in speed from 1.00 m/s to 2.00 m/s while the box slides 3.00 m, what is the magnitude of the force of the rope on the object?



a. 2.00 N b. 4.00 N c. 8.00 N d. 16.0 N e. 32.0 N

29. In the situation described in problem 28, what is the coefficient of kinetic friction between the object and the floor?

a. 0.069 b. 0.153 c. 0.466 d. 0.667 e. 0.707

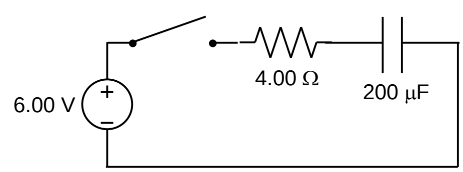
30. A fixed volume chamber contains 3.00 moles of ideal gas that have an initial temperature 20.0 °C and an initial absolute pressure 2.00 atmospheres. If the temperature rises to 40.0 °C and the absolute pressure rises to 6.00 atmospheres, how many additional moles of the gas have been added to the chamber during this process?

a. 1.50 moles b. 4.50 moles c. 5.43 moles d. 7.44 moles e. 9.21 moles

31. In a region where the magnetic field of the earth has a magnitude 25.0 μT and points vertically upward, an airplane with a wingspan 16.0 m flies due east at 200. m/s. In equilibrium, what is the electric potential difference between the two wing tips?

a. 40.0 mV b. 80.0 mV c. 160. mV d. 320. mV e. 640. mV

32. A 6.00 V voltage source, a switch (initially open), a 4.00 Ω resistor, and a 200 μF capacitor (with an initial voltage 0.00 V) are connected in series, as shown. If the switch is closed, how much time does it take for the capacitor voltage to rise to 3.00 V?



a. 3.33×10^{-4} s b. 4.00×10^{-4} s c. 5.55×10^{-4} s d. 8.00×10^{-4} s e. 8.88×10^{-4} s

33. At a particular point in space, there is destructive interference of the waves from two point sources of waves emitting the same wavelength in phase. This point is 4.00 m from one source and 3.00 m from the other source. Which of the following is a possible wavelength of the waves?

a. 1.00 m b. 2.00 m c. 3.00 m d. 3.50 m e. 4.00 m

34. A 4.00×10^5 kg space ship travels at a speed 0.500*c*. How much work must be done on the space ship to increase its speed to 0.800*c*?

a. 9.84×10^{20} J
b. 3.33×10^{21} J
c. 5.22×10^{21} J
d. 7.01×10^{21} J
e. 1.84×10^{22} J

35. A sample of material contains a single radioactive isotope with a half-life 20.0 minutes. At the time the activity of the sample is 2.00 μCi, how many atoms of the radioactive isotope are present? (1.0 Ci = 3.7×10^{10} decays/s)

a. 1.48×10^5 b. 1.48×10^6 c. 1.00×10^7 d. 1.48×10^7 e. 1.28×10^8