2013 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} $C^2/(N \cdot m^2)$
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} $N \cdot m^2/kg^2$
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 ^{o}C = 273.15 K

WYSE – Academic Challenge
Physics Test (Regional) – 2013

1. The statement, "no two electrons in an atom can have the same set of values for all four quantum numbers" is associated with

   a. De Broglie. b. Einstein. c. Compton. d. Pauli. e. Heisenberg.

2. When a distance runner is 235 m from the finish line, his speed is 3.00 m/s, but because he is tiring, his speed is decreasing at a constant rate of 0.0156 m/s each second. What will his speed be as he crosses the finish line?

   a. 1.72 m/s b. 1.29 m/s c. 2.31 m/s d. 2.71 m/s e. He will not finish.

3. At one instant the gravitational potential energy of a ball in vertical, free flight near the earth's surface is 45.0 J, while its kinetic energy at the same instant is 83.0 J. At a later instant, the kinetic energy of the ball is 34.0 J. What is the gravitational potential energy at this later instant?

   a. 49.0 J b. 162. J c. 4.00 J d. 72.0 J e. 94.0 J

4. For the situation in problem 3, if the speed of the ball at the later instant is 6.50 m/s, what is the mass of the ball?

   a. 1.61 kg b. 0.804 kg c. 5.23 kg d. 10.5 kg e. 2.32 kg

5. The principle known as conservation of charge is credited to

   a. Sir Isaac Newton.
   b. P. A. M. Dirac.
   c. Benjamin Franklin.
   d. Albert Einstein.
   e. Charles Coulomb.

6. The electron is a member of the family known as

   a. quark. b. lepton. c. baryon. d. meson. e. hadron.

7. A lens with a power of 4.00 diopters has a focal length of:

   a. 400. cm b. 25.0 cm c. 4.00 cm d. 50.0 cm e. 2.50 m

8. The intensity of sound could be measured in units of

a. $\frac{kg \cdot m^2}{s^3}$. b. $\frac{N}{m^2 \cdot s}$. c. $\frac{kg}{m^2 \cdot s}$. d. $\frac{kg \cdot m}{s}$. e. $\frac{kg}{s^3}$.

9. Use dimensional analysis to find the answer to the following problem:

A rocket is moving at a non-relativistic speed in a gravity free region of space and experiences no atmospheric drag. At some instant, the mass of the rocket is *M* (in kg), it expels fuel mass at the rate *R* (in kg/s) and the expelled fuel has an exhaust velocity relative to the rocket of *u* (in m/s). Relative to an inertial frame, what is the magnitude of the acceleration of the rocket at this instant?

a. $\frac{R}{M \cdot u}$ b. $R \cdot M \cdot u$ c. $\frac{R \cdot M}{u}$ d. $\frac{R \cdot u}{M}$ e. $\frac{M \cdot u}{R}$

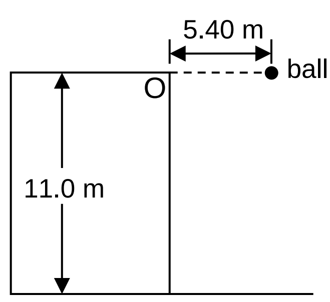
10. A 65.0 kg woman is riding on a 29.0 kg cart which is traveling without resistance at a speed of 3.40 m/s along a horizontal section of road. If she jumps off the cart such that her horizontal component of velocity is 0.00 m/s as seen by the earth frame, what is the **change** in speed of the cart?

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

11. For the situation in problem 10, if the duration of the woman's contact with the cart during the jumping action is 0.890 seconds, what is the magnitude of the average, horizontal component of force that the woman exerts on the cart?

a. 557 N b. 359 N c. 111 N d. 138 N e. 248 N

12. A 0.400 kg ball is released from rest 5.40 m to the right of point O and 11.0 m above the ground, as pictured in the diagram to the right. Relative to point O, how much torque does the force of gravity produce on the ball while the ball falls?

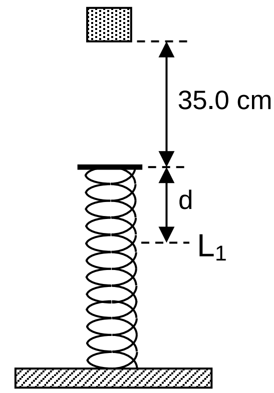


a. 0.00 N·m
b. 2.16 N·m
c. 21.2 N·m
d. 48.0 N·m
e. It varies with the distance fallen.

13. For the same situation as in problem 12, if the collision that the ball makes with the ground is perfectly elastic, what magnitude impulse will the ground exert on the ball when it bounces?

a. 5.87 N·s b. 0.00 N·s c. 7.84 N·s d. 11.7 N·s e. 29.4 N·s

14. A 2.50 kg block is released from rest from a distance 35.0 cm above the top, free end of a vertically oriented, massless spring of spring constant 1840 N/m. The bottom end of the spring is fixed to an immoveable, horizontal surface. What will be the maximum distance, d, the spring is compressed by the block, assuming the spring's natural length is greater than *d*? Assume that no energy is lost to heat or sound.



a. 9.65 cm
b. 7.52 cm
c. 0.472 cm
d. 97.9 cm
e. 11.1 cm

15. If the block in problem 14 sticks to the end of the spring when it makes contact with the spring, what minimum time does it take for the block's bottom surface to move from level L_1 (at maximum spring compression) to the level at which the spring force on the mass has the same value as the weight of the mass (the equilibrium position)?

a. 116 ms b. 6.78 s c. 57.9 ms d. 232 ms e. 36.8 ms

16. A 34.5 kg crate rests on a horizontal floor. The coefficient of static friction between the bottom of the crate and the floor is 0.448, while the coefficient of kinetic friction is 0.242. What minimum horizontal force must a person apply to start the crate moving?

a. 151 N b. 15.5 N c. 81.8 N d. 8.35 N e. 69.6 N

17. The position of an object in the x-y plane is given by: $x = -6.00t^2 + 8.00t - 4.00$ and $y = 4.00t^2 - 12.0t$, where x and y are in meters, and t is the time in seconds. What is the acceleration of the object? Note: **i** and **j** are unit vectors in the x and y directions, respectively. All answers are in m/s^2 .

a. -12.0**i** + 8.00**j**
b. +8.00**i** – 12.0**j**
c. -3.00**i** + 2.00**j**
d. +16.0**i** – 24.0**j**
e. +4.00**i** – 6.00**j**

18. For the situation in problem 17, what is the magnitude of the displacement of the object between t = 0.00 s and t = 0.500 s?

a. 1.22 m b. 2.50 m c. 5.22 m d. 5.59 m e. 7.50 m

19. A knowledge of kinematics may be used to solve the following problem.

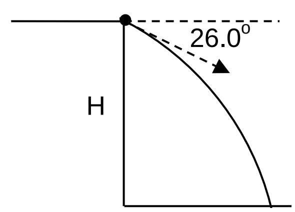
Using a controlled change in the the air pressure above the water surface in a closed vessel, the water's rate of exit through a valve at the bottom of the vessel has been programmed such that the exit rate when the valve is first opened is 0.750 gal/s, but the exit rate increases by 0.128 gal/s each second. If 45.0 gal of water are in the vessel when the valve is first opened, how much water is still in the vessel 14.0 s after the valve is opened?

a. 9.41 gal b. 22.0 gal c. 23.0 gal d. 32.7 gal e. 34.5 gal

20. A 30.0 ton railroad freight car collides with an initially stationary railroad flat car and couples with it. If the kinetic energy of the two-car system after coupling is 70.0% of the initial kinetic energy of the freight car, what is the weight of the flat car? (Assume that momentum is conserved during the collision.)

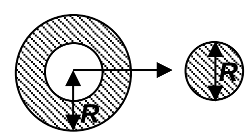
a. 12.9 ton b. 70.0 ton c. 21.0 ton d. 10.0 ton e. 14.7 ton

21. A small stone is projected from a building with an initial speed of 38.0 m/s and at an angle of 26.0^o below the horizontal, as shown. Assuming that air resistance is negligible, if the stone lands 65.5 m from the base of the building on the horizontal street below, how far above the street, height H, was the stone launched?



a. 210. m
b. 80.1 m
c. 50.0 m
d. 14.6 m
e. 31.9 m

22. A uniform disk has radius *R* and mass *M*. If a disk of radius *R*/2 is cut out of the center of the original disk, how much mass has been removed?

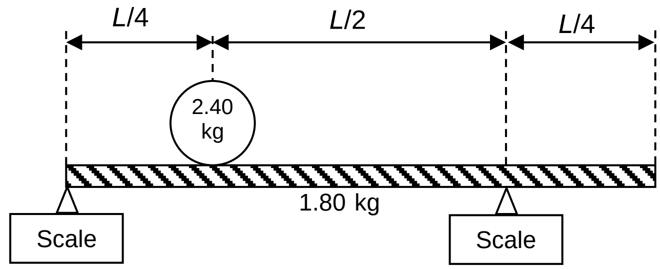


a. *M*/2 b. *M*/4 c. *M*/8 d. 3*M*/4 e. 7*M*/8

23. A force of 25.0 N due East acts upon an object of mass 13.5 kg. What additional force must act on the object if it is to have an acceleration of 3.00 m/s^2 East?

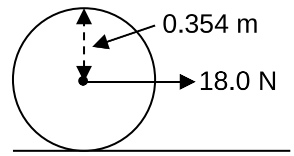
a. 62.5 N East
b. 29.5 N East
c. 20.5 N West
d. 15.5 N West
e. 15.5 N East

24. A uniform plank with mass 1.80 kg and length L is supported by two scales, as shown. A uniform sphere with mass 2.40 kg rests on the plank with its center a horizontal distance $L/4$ from the plank's left end. What will the reading on the right scale be?



a. 27.4 N b. 20.6 N c. 41.2 N d. 19.6 N e. 7.84 N

25. A horizontal force equal to 18.0 N pulls rightward on the axle of a 15.0 kg wheel of radius 0.354 m, causing it to roll without slipping and to have a constant acceleration of 0.564 m/s^2 rightward as it rolls over a horizontal surface. How much frictional force must exist between the surface and the wheel to produce the stated acceleration?

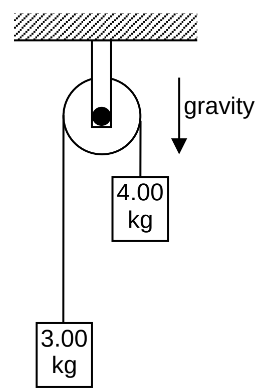


a. 0.00 N b. 8.46 N c. 9.54 N d. 26.5 N e. 4.23 N

26. For the situation in problem 25, if the wheel starts from rest, what is the speed of the center of the wheel after 4.50 s?

a. 18.2 m/s b. 0.898 m/s c. 5.71 m/s d. 7.17 m/s e. 2.54 m/s

27. An Atwood machine consists of a 3.00 kg block attached to a 4.00 kg block via a light, inextensible cord which is hung over a pulley attached to the ceiling. The pulley has negligible mass and friction. What is the tension in the cord connecting the two blocks?

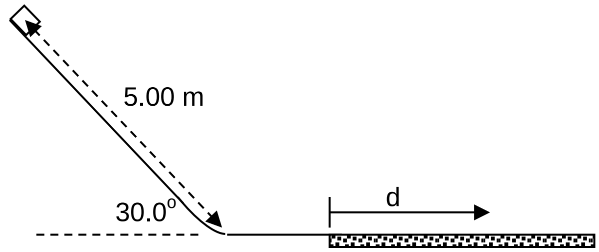


a. 29.4 N
b. 5.60 N
c. 68.6 N
d. 9.80 N
e. 33.6 N

28. A merry-go-round with a mass of 180. kg and a radius of 1.75 m rotates about a vertical axis through its center with an angular speed of 3.20 rad/s. The moment of inertia of the merry-go-round about its axis of rotation is 260. $\text{kg}\cdot\text{m}^2$. A 45.0 kg child drops from a limb above the merry-go-round, landing vertically, a distance 1.60 m from the axis of the merry-go-round. What is the angular speed of the merry-go-round after the child lands?

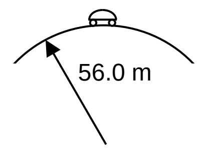
a. 2.09 rad/s b. 2.22 rad/s c. 2.62 rad/s d. 2.66 rad/s e. 2.90 rad/s

29. Released from rest, a block slides down a frictionless, 5.00 m incline which makes an angle of 30.0° with the horizontal. Soon after reaching the base of the incline, the block encounters a horizontal section with coefficient of kinetic friction equal to 0.450, causing the block to stop. What distance, d, along the rough section does the block travel before coming to rest?



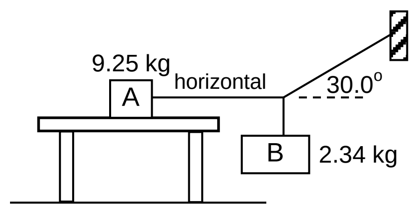
a. 5.56 m b. 11.1 m c. 9.62 m d. 6.41 m e. 1.12 m

30. A car is driven at a constant speed of 14.0 m/s as it travels over a bridge roadway which has a circular-shaped cross section, as shown. If the radius of curvature of the bridge roadway is 56.0 m, what upward force does the car exert on a 64.0 kg person riding in the car as it passes over the peak of the bridge roadway?



a. 611 N b. 627 N c. 224 N d. 403 N e. 851 N

31. The coefficient of static friction between block A and the table surface upon which it rests is 0.460. If the system of two blocks and light cords is in equilibrium, what is the tension in the horizontal cord?



a. 22.9 N b. 39.7 N c. 41.7 N d. 26.5 N e. 13.2 N

32. For the situation in problem 31, if the mass of block A is doubled, all else remaining the same, what happens to the frictional force acting on block A? The frictional force on A

a. remains the same.
b. doubles.
c. reaches its maximum value.
d. will decrease.
e. quadruples.

33. A bicycle wheel is given an initial spin of 7.00 rad/s. If the wheel rotates 14.0 revolutions before coming to rest, what is the magnitude of the average angular acceleration of the wheel?

a. 1.75 rad/s^2
b. 0.557 rad/s^2
c. 0.279 rad/s^2
d. 0.0796 rad/s^2
e. 0.500 rad/s^2

34. The specific heat of water is $1.00\ \text{cal/(g}\cdot\text{C}^{\text{o}})$. When heat is transferred to 180. g of water at a constant rate, *R*, for 3.00 min, its temperature increases by 17.0$^{\text{o}}$. When heat is applied at the same rate, *R*, to an unknown object of mass 300. g for a time of 6.00 min, its temperature increases by 95. 7$^{\text{o}}$. What is the specific heat of the unknown object?

a. $0.148\ \text{cal/(g}\cdot\text{C}^{\text{o}})$
b. $0.592\ \text{cal/(g}\cdot\text{C}^{\text{o}})$
c. $0.0533\ \text{cal/(g}\cdot\text{C}^{\text{o}})$
d. $0.213\ \text{cal/(g}\cdot\text{C}^{\text{o}})$
e. $0.107\ \text{cal/(g}\cdot\text{C}^{\text{o}})$

35. A proton is released from rest in a uniform electric field of magnitude 7.45×10^{4} N/C. What is the speed of the proton after it has moved a distance of 6.00 cm?

a. 2.80×10^{7} m/s
b. 6.54×10^{5} m/s
c. 9.25×10^{5} m/s
d. 6.54×10^{6} m/s
e. 3.97×10^{7} m/s