2013 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·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)

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 (Sectional) – 2013

1. A sprinter leaves the starting blocks from rest and accelerates uniformly for the first 20.0 m of a 100. m race. The speed of the sprinter is 12.0 m/s after this acceleration. What is the magnitude of the sprinter's constant acceleration during the first 20.0 m of the race?

   a. 0.600 m/s^2 b. 1.67 m/s^2 c. 3.60 m/s^2 d. 7.20 m/s^2 e. 10.0 m/s^2

2. In problem 1, if the sprinter runs with constant speed after the first 20.0 m to finish the 100. m race, how much time does it take for the sprinter to complete the entire 100. m race?

   a. 6.67 s b. 10.0 s c. 11.2 s d. 13.3 s e. 15.0 s

3. A 1500. kg car approaches an intersection traveling at 20.0 m/s toward the south. A 2000. kg truck approaches the same intersection traveling at 15.0 m/s toward the east. What is the magnitude of the car's velocity relative to the truck?

   a. 5.0 m/s
   b. 15.0 m/s
   c. 20.0 m/s
   d. 25.0 m/s
   e. 35.0 m/s

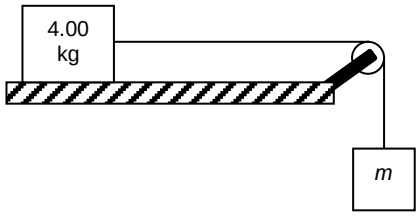
4. In problem 3, if the two vehicles collide completely inelastically at the intersection, what will be the velocity of the center of mass of the car-truck system immediately after the collision? Assume forces external to the car-truck system are negligible during the collision.

   a. 12.1 m/s in a direction 45.0° south of east
   b. 16.1 m/s in a direction 27.2° south of east
   c. 17.3 m/s in a direction 33.3° south of east
   d. 17.7 m/s in a direction 76.1° south of east
   e. 18.0 m/s in a direction 15.0° south of east

5. The electrical potential energy of a capacitor increases by 30.0 J when the voltage on the capacitor increases from 4.00 V to 8.00 V. What is the capacitance of the capacitor?

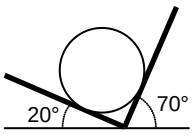
   a. 0.613 F b. 1.25 F c. 3.75 F d. 7.50 F e. 15.0 F

6. A 4.00 kg block on a level, frictionless surface is attached by a rope to a second block with mass *m* that is freely suspended from the end of the rope, as shown in the diagram. The pulley is frictionless, and the mass of the rope is negligible. If the magnitude of the acceleration of the blocks is 3.00 m/s^2, what is the mass *m*?



   a. 0. 249 kg b. 0.777 kg c. 0.938 kg d. 1.22 kg e. 1.76 kg

7. A 2.00 kg sphere rests in a frictionless, V-shaped groove, as shown in the diagram. What is the magnitude of the contact force of the sphere on the left side surface of the groove?



   a. 4.36 N b. 9.80 N c. 15.2 N d. 18.4 N e. 19.6 N

8. A blade assembly on a window fan has an initial angular speed of 50.0 rev/s and slows with a constant angular acceleration of magnitude 2.00 rad/s^2 when the power is turned off. How much time does it take the blade assembly to come to rest?

   a. 25.0 s b. 43.7 s c. 78.5 s d. 157. s e. 799. s

9. In problem 8, if the magnitude of the torque about the axis of rotation acting on the blade assembly is 0.400 N·m, what is the moment of inertia of the blade assembly about the axis of rotation?

   a. 0.200 kg·m^2 b. 0.800 kg·m^2 c. 5.00 kg·m^2 d. 20.0 kg·m^2 e. 125. kg·m^2

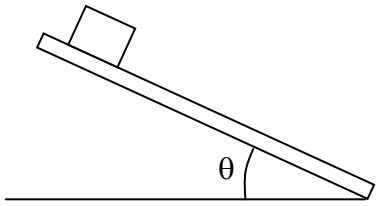
10. The parallel axis theorem states that the moment of inertia, I_A, of an object about axis A, is equal to the moment of inertia, I_B, about axis B, which is parallel to axis A, added to the mass of the object, m, multiplied by the square of the distance of A from B, d, (i.e. $I_A = I_B + md^2$), only if

    a. axis A passes through the origin of the coordinate system.
    b. axis B passes through the origin of the coordinate system.
    c. axis A passes through the center of mass of the object.
    d. axis B passes through the center of mass of the object.
    e. the object is cylindrically symmetric about axis A.

11. A 70.0 kg skydiver opens her parachute and a moment later her acceleration is 2.00 m/s^2 upward. If air drag forces on her body are negligible, what is the total upward component of force of the parachute shroud lines on the skydiver at that moment?

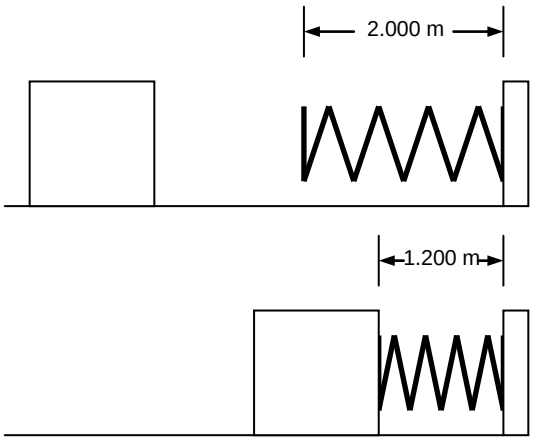
    a. 140. N b. 366. N c. 546. N d. 686. N e. 826. N

12. A 3.00 kg block rests on a flat plank. The coefficient of kinetic friction between the block and the plank is 0.400, and the coefficient of static friction between the block and the plank is 0.500. If the plank is tilted at angle θ above horizontal, which would be the greatest θ in the list of responses at which the block would not begin to slide down the plank?



    a. 18° b. 28° c. 38° d. 48° e. 58°

13. A 3.00 kg block is sliding to the right at 1.50 m/s on the level, frictionless surface as shown in the upper diagram. It strikes the end of the spring and compresses it as shown in the lower diagram. When the block is in the position shown in the lower diagram, its speed is 1.00 m/s. What is the spring constant of the spring?



    a. 1.07 N/m
    b. 1.89 N/m
    c. 2.44 N/m
    d. 2.93 N/m
    e. 5.86 N/m

14. The total linear momentum of a system is a conserved quantity only if

a. no net external force acts on the system.
b. the total kinetic energy of the system is conserved.
c. no forces act within the system.
d. no non-conservative forces act within the system.
e. the temperature of the system remains constant.

15. A solid has a specific heat, 800. J/kg·C°, a heat of fusion, 4.00×10^4 J/kg, a heat of vaporization, 9.00×10^4 J/kg, and a melting temperature, 40.0 °C. How much heat must be added to the sample to completely melt a 2.00 kg sample of the solid that is initially at a temperature −20.0 °C ?

a. 8.00×10^4 J
b. 9.60×10^4 J
c. 1.76×10^5 J
d. 2.76×10^5 J
e. 5.56×10^5 J

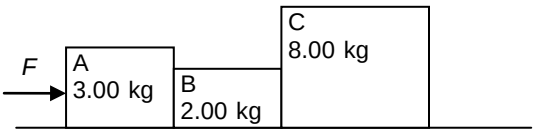
16. The magnitude of the electric field at a point that is a distance *d* away from an isolated point charge is

a. independent of *d.*
b. directly proportional to *d.*
c. inversely proportional to *d.*
d. directly proportional to d^2.
e. inversely proportional to d^2.

17. A sample of a radioactive isotope has an initial decay rate 2.00×10^6 decays per second at 1:00:00 pm. Later the same day at 4:00:00 pm, the decay rate has decreased to 3.00×10^4 decays per second. What is the half-life of the isotope?

a. 0.0050 hr b. 0.495 hr c. 1.00 hr d. 2.22 hr e. 2.37 hr

18. Three blocks are being pushed by constant force $\boldsymbol{F}$ along a frictionless, horizontal surface. If $\boldsymbol{F}_{BC}$ is the contact force on block B from block C, and $\boldsymbol{F}_{BA}$ is the contact force on block B from block A, what is the ratio of magnitudes: $|\boldsymbol{F}_{BC}| / |\boldsymbol{F}_{BA}|$?



a. 1.25 b. 0.167 c. 0.769 d. 0.800 e. 0.615

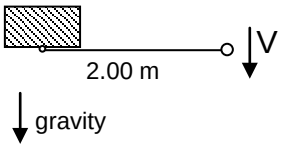
19. Two forces act upon a 15.0 kg mass. One is 10.0 N acting due East. The other is 10.0 N acting due South. In what direction does the mass have NO component of acceleration?

a. 45.0° West of North
b. 45.0° West of South
c. 45.0° South of East
d. due West
e. No such direction exists.

20. A bowling ball is in a circular orbit about the Earth. The period of the bowling ball's orbit does NOT depend significantly upon the

a. universal gravitational constant.
b. mass of the planet.
c. mass of the bowling ball.
d. radius of the orbit.
e. speed of the bowling ball.

21. A small sphere of mass 0.150 kg, at the end of an unstretchable pendulum string of length 2.00 m, has velocity *V* downward when the string is horizontal. The forces acting on the sphere at this instant are due to the string's tension and gravity. What must be the value of *V* so that the magnitude of the sphere's total acceleration at this instant be 2.00 times the acceleration due to gravity (at the Earth's surface)?



a. 19.6 m/s b. 5.83 m/s c. 4.43 m/s d. 6.26 m/s e. 8.24 m/s

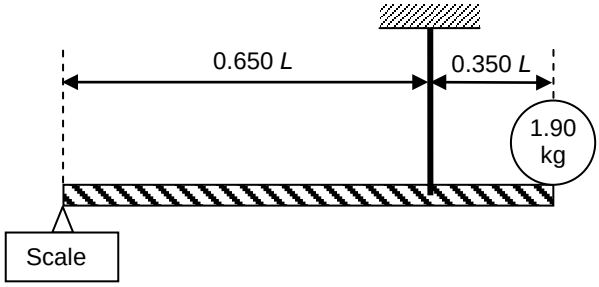
22. In problem 21, suppose the speed of the sphere at the starting position (when the string is horizontal) is 7.00 m/s. Assuming that friction forces are negligible, how fast will the sphere be moving when its vertical position is 1.50 m lower than its initial vertical position?

a. 9.13 m/s b. 6.26 m/s c. 7.67 m/s d. 7.98 m/s e. 8.85 m/s

23. As a classical (non-quantum mechanical) wave propagates, some of its energy is transferred to heat. This causes a reduction in the wave's

a. period.
b. frequency.
c. speed.
d. wavelength.
e. amplitude.

24. A uniform plank having length *L* and weight *W* is supported by a cord at a distance 0.350 *L* from the right end of the plank, and by a scale at the plank's left end, as shown. A uniform sphere with mass 1.90 kg rests on the plank with its center above the right end of the plank. If the reading on the scale is 0.125 *W*, what is the weight of the plank?



a. 94.8 N b. 9.67 N c. 80.2 N d. 28.2 N e. 43.4 N

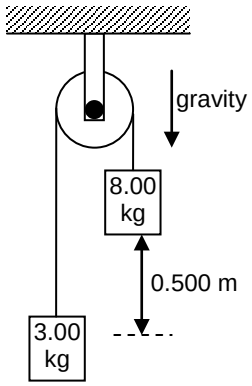
25. The position of a certain particle moving along the x axis is given by the following function of time *t*: $x(t) = \left(20.000\ \text{m/s}^2\right)t^2 + \left(30.000\ \text{m/s}^3\right)t^3$. What is the average speed of the particle between *t* = 0.000 s and *t* = 0.100 s?

a. 2.30 m/s b. 2.45 m/s c. 4.90 m/s d. 1.15 m/s e. 0.230 m/s

26. As a baseball player whose mass is 58.0 kg slides into third base, the frictional force acting on the player is 355 N. What is the coefficient of kinetic friction between the player and the ground?

a. 1.60 b. 0.0172 c. 0.163 d. 6.12 e. 0.625

27. An 8.00 kg block is attached to a 3.00 kg block via a light, inextensible cord which is hung over a pulley attached to the ceiling. However, the pulley is stuck and unable to rotate, so it exerts a 12.5 N frictional force on the cord as the cord slides over the pulley. If the two blocks start from rest, how fast will they be moving when the 8.00 kg mass has fallen a distance of 0.500 m?

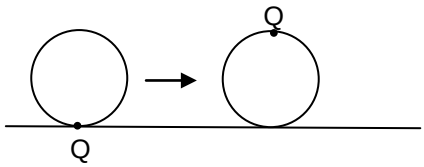


a. 2.11 m/s
b. 2.45 m/s
c. 2.67 m/s
d. 1.82 m/s
e. 3.32 m/s

28. What is the rotational inertia of a wheel that is spinning about a fixed axis if it has an angular momentum of magnitude $4.81\times10^{3}\ \text{kg}\cdot\text{m}^2/\text{s}$ and a kinetic energy of 1.53×10^{5} J?

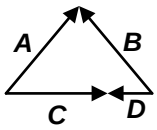
a. $37.8\ \text{kg}\cdot\text{m}^2$
b. $31.8\ \text{kg}\cdot\text{m}^2$
c. $75.6\ \text{kg}\cdot\text{m}^2$
d. $0.0314\ \text{kg}\cdot\text{m}^2$
e. $63.6\ \text{kg}\cdot\text{m}^2$

29. A wheel of radius 45.2 cm rolls Eastward, without slipping, along a horizontal surface. Initially point Q, on the periphery of the wheel, is in contact with the horizontal surface. One half revolution later, point Q is at the top of the wheel. What is the magnitude of the displacement of Q between these two points?



a. 187 cm b. 149 cm c. 168 cm d. 298 cm e. 232 cm

30. What is the relationship between the displacement vectors shown in the diagram shown below?



a. $A + C = D + B$
b. $A - B = D - C$
c. $A + B + D + C = 0$
d. $A + -C = -D + B$
e. None of the above are correct.

31. The transverse wave speed on a certain taut string, tied between rigid supports, is 72.1 m/s. If the fundamental frequency produced by the string is 110. Hz, what is the length of the string?

a. 0.655 m b. 0.328 m c. 0.762 m d. 1.53 m e. 0.164 m

32. A solid iron cannonball (of density 7860 kg/m^3) appears to be 234 N lighter in water (of density $1.00\times10^{3}\ \text{kg/m}^3$) than in air. What is the volume of the cannonball?

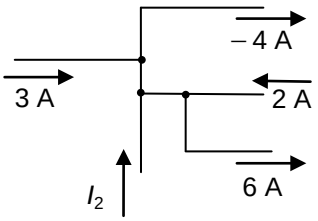
a. $0.0239\ \text{m}^3$ b. $0.00304\ \text{m}^3$ c. $0.00348\ \text{m}^3$ d. $2.99\ \text{m}^3$ e. $0.234\ \text{m}^3$

33. A 150. W immersion heater is to be used to heat 185 g of water from 23.6 ^{o}C to the boiling point of water. Noting that the specific heat of water is 4.19 J/g/C^{o}, and assuming that all of the electrically generated heat stays with the water, how long does it take to bring the water to the verge of boiling?

a. 395 s b. 517 s c. 122 s d. 974 s e. 260 s

34. What is the value of current I_2 in the partial circuit shown?

a. 1 A
b. 7 A
c. 3 A
d. −3 A
e. −7 A



A denotes amps.

35. An object is placed to the left of a thin lens and on the optic axis, as shown. The lens produces an inverted image of this object. If the image is 56.0 cm away from the object, and is 0.400 times the object's height, how far is the lens from the object?

a. 16.0 cm
b. 11.4 cm
c. 22.4 cm
d. 33.6 cm
e. 40.0 cm