THE 31st ANNUAL SLAPT PHYSICS CONTEST
COMPREHENSIVE PHYSICS TEST

$g = 9.8\ m/s^2$	$1cm^3$ = milliliter	R = 8.314 J/mol/K
$e = 1.6 \times 10^{-19}\ C$	The Coulomb constant, $k = 8.99 \times 10^9 N \cdot m^2/C^2$	
$c = 3.0 \times 10^8 m/s$	The value of Boltzmann's constant k= 1.38 × 10-23 J/K	

1. In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in the distance they travel by a multiple of:
a. a fourth of a wavelength
b. a half a wavelength
c. a wavelength
d. three-fourths of a wavelength
e. none of the above

2. A solid disk of radius 1.60 m and mass 2.30 kg rolls without slipping to the bottom of an inclined plane. If the angular velocity of the disk is 5.35 rad/s at the bottom, what is the height of the inclined plane
a. 5.61 m
b. 4.94 m
c. 4.21 m
d. 3.73 m

3. A hollow steel ball of diameter 3 m barely floats in water. What is the wall thickness of the ball? ($\rho Fe = 7.87\ g/cm^3$)
a. 1.3 cm
b. 4.2 cm
c. 6.6 cm
d. 37 cm

4. A gamma ray (a pulse of electromagnetic energy) has a frequency of 2.42×10^{20} Hz. What is the ratio of its wavelength to the radius of the nucleus which produced it (radius = 5.0×10^{-13} cm)?
a. 0.0015
b. 39.4
c. 248
d. 1.21×10^8

5. If the mass of a particle is zero its speed must be:
a. c
b. infinite
c. 0
d. any speed less than c
e. any speed greater than c

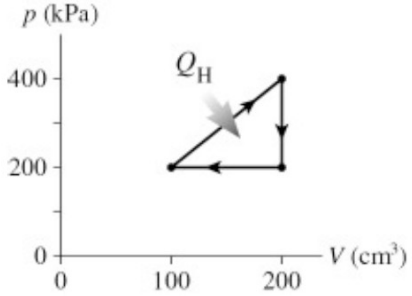
6. A motor drives a mechanism that produces simple harmonic motion at one end of a stretched cable such that the oscillation amplitude is 25.1 cm. What is the wave amplitude when the power of the motor is increased by 25.1%? Assume that the frequency oscillation and tension in the wire are unchanged.
a. 25.3 cm
b. 25.8 cm
c. 28.1 cm
d. 33.7 cm

7. Two motors in a factory are running at slightly different rates. One runs at 825 rpm and the other at 786 rpm. You hear the sound intensity increase and then decrease periodically due to wave interference. How long does it take between successive instances of the sound intensity increasing?
a. 1.54 s
b. 1.63 s
c. 1.66 s
d. 1.79 s

8. What is the phase difference between (a) the displacement and the potential energy and (b) the displacement and the kinetic energy at a fixed point of a harmonic wave on a string?
a. (a) 0 (b) 0
b. (a) $\pi/2$ (b) 0
c. (a) 0 (b) $\pi/2$
d. (a) $\pi/2$ (b) $\pi/2$

9. The figure shows a cycle for a heat engine for which QH=35 J. What is the thermal efficiency

a. 15%
b. 23%
c. 25%
d. 29%



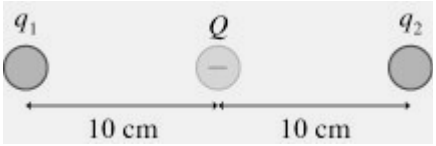
10. A cork bobs on the surface of the water making an oscillation every 3.0 s, with an amplitude of 1.0 m. Another cork 18.0 m away is observed to bob exactly 180° out of phase with the first cork. What is the velocity of the water waves?
a. 2.0 m/s
b. 4.0 m/s
c. 18 m/s
d. 25 m/s

11. Eleven molecules have speeds 16, 17, 18, . . . , 26 m/s. Calculate v_{rms}
a. 21.2 m/s
b. 21.5 m/s
c. 21.7 m/s
d. 22.0 m/s

12. What is the average kinetic energy of an ideal gas at 842 K?
a. 5.81×10^{-21} J
b. 1.74×10^{-20} J
c. 3.93×10^{-19} J
d. 1.18×10^{-17} J

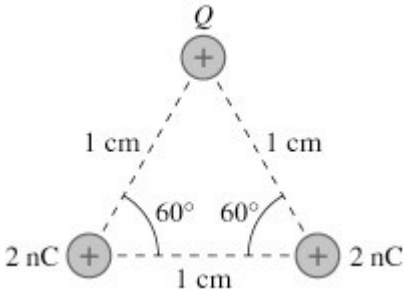
13. An ideal gas in a balloon is kept in thermal equilibrium with its constant temperature surroundings. How much work is done by the gas if the pressure is slowly reduced and the balloon expands to 6.0 times its original size?
The balloon initially has a pressure of 645.0 Pa and has a volume of 0.10 m^3
a. –330 J
b. 120 J
c. 330 J
d. 390 J

14. In the figure below the charge in the middle is Q = -3.1 nC. For what charge q1 will charge q2 be in static equilibrium?



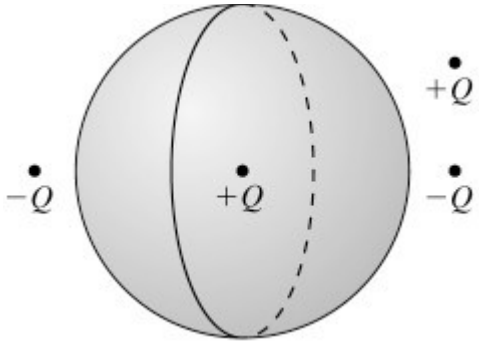
a. 25 nC
b. 6.2 nC
c. 3.1 nC
d. 12 nC

15. In the figure Q = 5.8 nC and all other quantities are exact. What is the magnitude of the force on the charge Q?



a. 0.9 mN
b. 1.0 mN
c. 1.2 mN
d. 1.8 mN

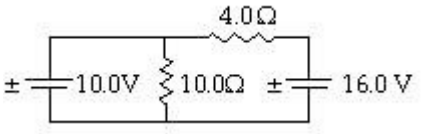
16. A particle with a charge +Q is inside a spherical Gaussian surface, and three other charges (one with a charge +Q and two with a charge -Q) are outside the Gaussian surface, as shown.



The net electric flux through the surface is:
a. Greater than zero
b. Less than Zero
c. Equal to zero

17. The electric field 1.5 cm from a small object points toward the object with a strength of 180,000 N/C. What is the object's charge?
a. –4.5nC
b. 4.5 nC
c. –5.0 nC
d. 5 nC

18. Refer to the figure. What is the current through the 4.0 Ω resistor?



a. 1.1 A
b. 1.5 A
c. 4.0 A
d. 0.43A

19. The speed of light in a material is 0.50 *c*. What is the critical angle of a light ray at the interface between the material and a vacuum
a. 21°
b. 24°
c. 27°
d. 30°

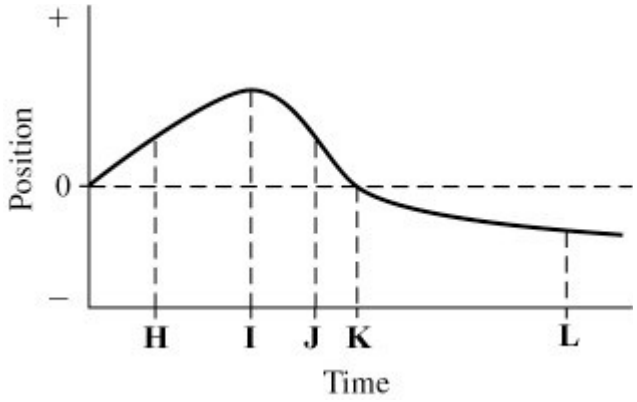
20. An ancient rock is found to contain ^{40}Ar gas, indicating that 77% of the ^{40}K in the rock has decayed since the rock solidified. Any argon would have boiled out of liquid rock. How long ago did the rock solidify? The half-life of ^{40}K is 1.25 billion years.
a. 0.3 billion years
b. 1.8 billion years
c. 2.6 billion years
d. 3.2 billion years

21. What is the basic difference between Schrodinger's equation and Newton's 2nd law?
a. Newton's 2nd can be used to predict exactly where a particle will be at any given time, where as solutions to Schrodinger's equation only give probabilities.
b. Newton's 2nd law is only valid for big objects (like balls) and the Schrodinger equation is only valid for small objects (like atoms and electrons).
c. Energy is conserved in Newton's 2nd law, but not in Scrhodinger's Equation

22. Acceleration is sometimes expressed in multiples of *g*, where g = 9.8 m/s^2 is the acceleration due to the earth's gravity. In a car crash, the car's velocity may go from 26 m/s to 0 m/s in 0.15 s. How many *g*'s are experienced, on average, by the driver?
a. 13 g
b. 18 g
c. 22 g
d. 23 g

23. At the same moment, one rock is dropped and one is thrown downward with an initial velocity of 10 m/s from the top of a 300 m building. How much earlier does the thrown rock strike the ground?
a. 0.95 s
b. 1.05 s
c. 2.10 s
d. They land at the same time

24. The plot below shows the position of an object as a function of time. The letters H-L represent particular moments of time. At which moment in time is the speed of the object the highest?



a. H
b. I
c. J
d. K

25. Two vehicles approach a right angle intersection and then collide. After the collision, they become entangled. If their mass ratios were 1: 5 and their respective speeds as they approached were 16 m/s and 17 m/s, find the final velocity of the wreck
a. 14.4 m/s at 79°
b. 16.9 m/s at 79°
c. 17.3 m/s at 79°
d. 19.2 m/s at 79°

26. The siren of an ambulance wails at 1395 Hz when the ambulance is stationary.
What frequency will you hear after this ambulance passes you while traveling at 33.60 m/s? The speed of sound under the prevailing conditions is 343.0 m/s.
a. 1052 Hz
b. 1271 Hz
c. 1395 Hz
d. 1547 Hz

27. Which of the following statements about the speed of waves on a string are true?
I. The speed depends on the tension in the string.
II. The speed depends on the frequency.
III. The speed depends on the mass per unit length of the string.

a. II only
b. I & II only
c. I & III only
d. II & III only
e. I, II, & III

28. Which device can be used to detect nuclear radiation?
a. cyclotron
b. photographic film
c. betatron
d. synchrotron
e. Van de Graaff

29. You are given three 1.0 W resistors. Which of the following equivalent resistances *CANNOT* be produced using all three resistors?
a. 1/3 W
b. 2/3 W
c. 1.0 W
d. 1.5 W
e. 3.0 W

30. The driver of an automobile must carefully control each of the following devices. Which of these devices can cause an acceleration in a moving car?
1) the break pedal 2) the gas pedal 3) the steering wheel
a .only number 1
b. only number 2
c. only number 3
d. only numbers 1 and 2
e. numbers 1, 2, and 3

31. Three different resistors $R1$, $R2$ and $R3$ are connected in parallel to a battery. Suppose $R1$ has 2 V across it, $R2$ = 4 W, and $R3$ dissipates 6 W. What is the current in $R3$?
a. 0.33 A
b. 0.5 A
c. 2 A
d. 3 A
e. 12 A

32. A certain string on a piano is tuned to produce middle C (f = 261.63 Hz) by carefully adjusting the tension in the string. For a fixed wavelength, what is the frequency when this tension is doubled?
a. 130.08 Hz
b. 185.00 Hz
c. 370.00 Hz
d. 446.63 Hz
e. 523.26 Hz

33. Two boys are whispering in the library. The radiated sound power from one boy's mouth is 1.2×10^{-9} W; and it spreads out uniformly in all directions. What is the minimum distance the boys must be away from the librarian so that she will not be able to hear them? The threshold of hearing for the librarian is 1.00×10^{-12} W/m^2.
a. 100 m
b. 35 m
c. 23 m
d. 16 m
e. 9.8 m

34. Which one of the following statements best explains why convection does not occur in solids?
a. Molecules in a solid are more closely spaced than in a gas.
b. The molecules in a solid are not free to move throughout the volume of the solid.
c. Molecules in a solid vibrate at a lower frequency than those in a liquid.
d. Solids are more compressible than liquids.
e. Solids are less compressible than gases.

35. A charge Q exerts a 12 N force on another charge q. If the distance between the charges is doubled, what is the magnitude of the force exerted on Q by q?
a. 3 N
b. 6 N
c. 24 N
d. 36 N
e. 48N

36. Sara puts a box into the trunk of her car. Later, she drives around an unbanked curve that has a radius of 48 m. The speed of the car on the curve is 16 m/s, but the box remains stationary relative to the floor of the trunk. Determine the minimum coefficient of static friction for the box on the floor of the trunk.
a. 0.42
b. 0.54
c. 0.17
d. 0.33
e. This cannot be determined without knowing the mass of the box.

37. A force acting on an object moving along the x axis is given by $F\text{x} = (14x - 3.0x^2)$ N, where x is in m.
How much work is done by this force as the object moves from $x = -1$ m to $x = +2$ m?
a. +12 J
b. +28 J
c. +40 J
d. +42 J
e. –28 J

38. A 51-kg woman runs up a flight of stairs in 5.0 s. Her net upward displacement is 5.0 m. Approximately, what average power did the woman exert while she was running?
a. 5.0 kW
b. 1.0 kW
c. 0.75 kW
d. 0.50 kW
e. 0.25 kW

39. The position of a particle moving along the x axis is given by $x = 6.0t^2 - 1.0t^3$, where x is in meters and t in seconds. What is the position of the particle when it achieves its maximum speed in the positive x direction?
a. 24 m
b. 12 m
c. 32 m
d. 16 m
e. 2.0 m

40. The bending of light as it moves from one medium to another with differing indices of refraction is due to a change in what property of the light?
a. amplitude
b. period
c. frequency
d. speed
e. color

41. When certain light rays pass from a vacuum into a block of an unknown material, the measured index of refraction of the material is 3.50. What is the speed of light inside the block?

a. 1.0×10^7 m/s

b. 4.8×10^7 m/s

c. 8.6×10^7 m/s

d. 1.9×10^8 m/s

e. 2.9×10^8 m/s

42. How many electrons flow through a battery that delivers a current of 3.0 A for 12 s?

a. 4

b. 36

c. 4.8×10^{15}

d. 6.4×10^{18}

e. 2.2×10^{20}

Questions 43 and 44 pertain to the situation described below:

A periodic transverse wave is established on a string such that there are exactly two cycles traveling along a 3.0-m section of the string. The crests move at 20.0 m/s.

43. How long does it take a particle at the top of a crest to reach the bottom of an adjacent trough?

a. 0.018s

b. 0.038s

c. 0.075s

d. 0.150s

e. 0.30s

44. How could the speed of the wave be increased?

a. by increasing the period

b. by decreasing the amplitude

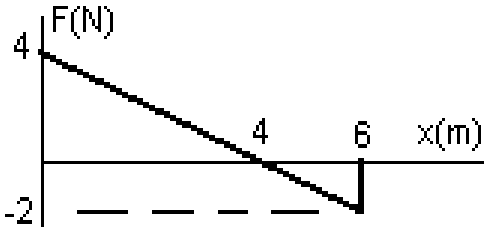
c. by decreasing the frequency

d. by increasing the tension in the string

e. by increasing amplitude

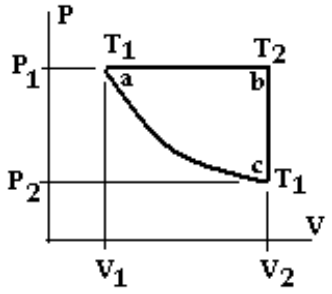
45. A bell is ringing inside of a sealed glass jar that is connected to a vacuum pump. Initially, the jar is filled with air. What does one hear as the air is slowly removed from the jar by the pump?
a. The sound intensity from the bell gradually decreases.
b. The frequency of the sound from the bell gradually increases.
c. The frequency of the sound from the bell gradually decreases.
d. The speed of the sound from the bell gradually increases.
e. The intensity of the sound from the bell does not change.

46. A certain crane can provide a maximum lifting force of 25 000 N. It hoists a 2000-kg load starting at ground level by applying the maximum force for a 2-second interval; then, it applies just sufficient force to keep the load moving upward at constant speed. Approximately how long does it take to raise the load from ground level to a height of 30 m?
a. 2s
b. 5s
c. 7s
d. 9 s
e. 10s



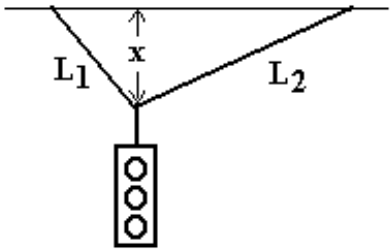
47. The above graph shows the force in x direction on an object as it moves a distance x. What is the work done by the force when the object moves from 0.0 m to 6.0 m?
a. 14 J
b. 12 J
c. 10 J
d. 8 J
e. 6 J

USE THIS DIAGRAM FOR THE NEXT TWO QUESTIONS



48. The PV diagram for one mole of an ideal gas is shown in the figure above. P1 = 3 atm, P2 = 1 atm, V1 = 7 liters, and V2 = 21 liters. What is the temperature T1 at point a?
a. 256 K
b. 200 K
c. 175 K
d. 115 K
e. 100 K

49. One mole of an ideal gas undergoes an isometric process from point b to point c in the figure above. P1 = 3 atm, P2 = 1 atm, V1 = 7 liters, and V2 = 21 liters. What is the work done by or on the system?
a. 0J
b. 2,740 J
c. 4,260 J
d. 6,380 J
e. 7,230 J



50. A 100 N traffic light is suspended by two wires of length L_1 and L_2 as shown in the figure. If L_1 = 3.0m and L_2 = 5.0 m and the distance x = 2.0 m, then the tension in the wire of length L_1 is,
a. 125 N
b. 101 N
c. 90 N
d. 82 N
e. 75 N