THE TWENTY-THIRD ANNUAL SLAPT PHYSICS CONTEST
SOUTHERN ILLINOIS UNIVERSITY EDWARDSVILLE
APRIL 26, 2008
9 – 11 AM

COMPREHENSIVE PHYSICS TEST

$g = 9.8$ m/s/s $1cm^3$ = milliliter $R = 8.314$ J/mol/K

$e = 1.6 \times 10^{-19}$ C The Coulomb constant, $k = 8.99 \times 10^9$ N·m^2/C^2

$c = 3.0 \times 10^8$ m/s

Please answer the following questions on the supplied answer sheet. You may write on this test booklet and keep it for your records. Only the answer sheets will be scored

The cash prizes for this exam will be:
First Prize of $150, Second Prize of $75, and Third Prize of $25.

Certificates of Honorable Mention will be presented to the next highest scoring twenty percent of the contestants, and certificates to the top three scoring schools.

Award Ceremony at 12:30 in this room

Need something to do until 12:30:

2nd Annual Greater St. Louis Botball Challenge

Robots from 4 states will be converging on the SIUE Campus this Saturday for the 2nd annual Greater St. Louis Botball Tournament. 18 teams from Illinois, Indiana, Michigan and Missouri middle and high schools will put their robots to the test in a head-to-head competition.

When: Saturday, April 26th (today). Doors open at 8 am, Seeding rounds begin at 9:30 am, Double Elimination rounds begin about 1:30 pm
What: Autonomous robots (no remote control!) will save crew and plants on a space station facing a massive solar flare.
Where: The Meridian Ballroom in the Morris University Center
Who: Everyone is welcome! Come see the robots! Cheer on your favorite school!

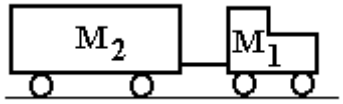
1) A car travels at 50 km/hr for 2 hours. It then travels an additional distance of 40 km in 1 hour. The average speed of the car for the entire trip is,
a) 61.0 km/hr
b) 57.1 km/hr
c) 53.3 km/hr
d) 46.7 km/hr
e) 30.0 km/hr

2) A 3.0 kg ball is thrown vertically into the air with an initial velocity of 15 m/s. The maximum height of the ball is,
a) 12.0 m
b) 11.5 m
c) 10.0 m
d) 9.5 m
e) 9.0 m

3) A car starting from rest travels a distance of 20.0 m with a constant acceleration of 2.0 m/s^2. The car then slows to a stop in 10.0 seconds with a constant negative acceleration. The distance traveled by the car is,
a) 36.8 m
b) 46.2 m
c) 50.1 m
d) 58.3 m
e) 64.7 m

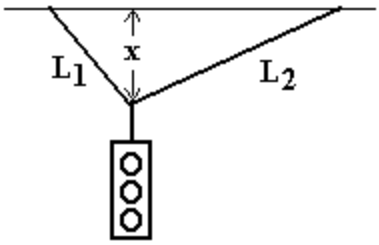
4) A rocket is launched from the origin with an acceleration of 20.0 m/s^2 at an angle of 30 above the horizontal. The launch acceleration lasts for 2.0 seconds at which time the fuel is exhausted. The rocket then falls with an acceleration of 9.8 m/s^2 downward. What is the maximum height?
a) 22.3 m
b) 27.5 m
c) 30.5 m
d) 36.7 m
e) 40.4 m

5) An airplane is flying in horizontal flight at a constant velocity. The weight of the airplane is 40,000 N. The wings produce a lift force that is perpendicular to the wings and a drag force that is parallel to the wing. The engine produces a forward thrust force of 2,000 N. Which of the following statements is true?
a) The lift force on the airplane is zero.
b) The drag force on the airplane is zero.
c) The lift force on the airplane is 42,000 N upward.
d) The drag force on the airplane is 38,000 N downward.
e) The drag force on the airplane is 2,000 N backward.



6) A tractor of mass M1 = 2,000 kg is pulling a trailer of mass M2 = 5,000 kg. If the tractor-trailer is accelerated at 2.0 m/s^2 , then the tension in the trailer hitch that connects the trailer to the tractor is,

a) 6,000 N
b) 8,000 N
c) 9,000 N
d) 10,000 N
e) 11,000 N

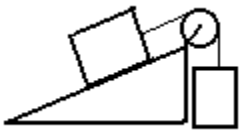


7) A 100 N traffic light is suspended by two wires of length L1 and L2 as shown in the figure. If L1 = 3.0 m and L2 = 5.0 m and the distance x = 2.0 m, then the tension in the wire of length L1 is,

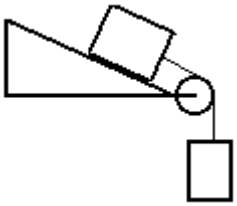
a) 125 N
b) 101 N
c) 90 N
d) 82 N
e) 75 N

8) A cord with a tension T is passes over a pulley as shown in the figure. The angle θ is 30 degrees and the tension T is 120 N. The force on the pulley by the shaft that supports the pulley is,

a) Fx = 60.0 N, Fy = 16.1 N
b) Fx = 16.1 N, Fy = 60.0 N
c) Fx = 60.0 N, Fy = 60.0 N
d) Fx = 30.0 N, Fy = 90.0 N
e) Fx = 90.0 N, Fy = 30.0 N



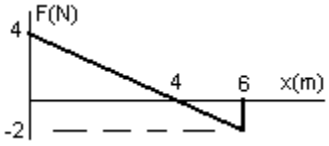
9) Two masses are connected by a string which passes over a frictionless, mass less pulley. One mass hangs vertically and one mass slides on a 30 degrees frictionless incline. The vertically hanging mass is 6.0 kg and the mass on the incline is 4.0 kg. The acceleration of the 4.0 kg mass is,
a) 0.98 m/s^2
b) 3.92 m/s^2
c) 5.75 m/s^2
d) 6.86 m/s^2
e) 7.84 m/s^2



10) Two masses are connected by a string which passes over a frictionless, mass less pulley. One mass hangs vertically and one mass slides on a 30 degrees incline. The vertically hanging mass is 4.0 kg and the mass on the frictionless incline is 6.0 kg. The acceleration of the 4.0 kg mass is,
a) 0.98 m/s^2
b) 3.92 m/s^2
c) 5.75 m/s^2
d) 6.86 m/s^2
e) 7.84 m/s^2

11) A 2000 kg car is traveling on a banked curved icy road. The velocity of the car is 25 m/s and the road has a radius of curvature of 500 m. If the car is to travel on the icy road without sliding, then the angle of the banked road is,
a) 25.7 degrees
b) 21.0 degrees
c) 12.7 degrees
d) 10.5 degrees
e) 7.27 degrees

12) A 5.0 kg box slides up a 10 m long friction incline at an angle of 20 degrees with the horizontal pushed by a 40 N force parallel to the incline. The coefficient of kinetic friction is 0.1. The change in kinetic energy is,
a) 105 J
b) 145 J
c) 186 J
d) 200 J
e) 243 J



13) 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

14) A spring-powered dart gun is un-stretched and has a spring constant 12.0 N/m. The spring is compressed by 8.0 cm and a 5.0 gram projectile is placed in the gun. The velocity of the projectile when it is shot from the gun is,
a) 1.52 m/s
b) 2.54 m/s
c) 3.92 m/s
d) 4.24 m/s
e) 5.02 m/s

15) The explosion in a cannon exerts an average force of 30,000 N for L meters, the length of the cannon. The length of the cannon to shoot a 2.0 kg projectile from the cannon on the earth to the moon is,
a) 2.75 km
b) 3.01 km
c) 3.98 km
d) 4.26 km
e) 5.02 km

16) An astronaut in a space suit is motionless in outer space. The propulsion unit strapped to her back ejects some gas with a velocity of 40 m/s. The astronaut recoils with a velocity of 1.0 m/s. If the mass of the astronaut and space suit after the gas is ejected is 100 kg and the mass of the gas ejected is 2.5 kg, then the total kinetic energy after the ejection of the gas is,
a) 2,050 J
b) 3,430 J
c) 4,150 J
d) 5,070 J
e) 0 J

17) A 4.0 kg object is moving at 5.0 m/s 45° NORTH of WEST. It strikes a 6.0 kg object that is moving 45° SOUTH of WEST at 2.0 m/s. The objects have a completely inelastic (stick together) collision. The velocity of the 6.0 kg object after the collision is,
a) 2.33 m/s at an angle of 45.0 degrees NORTH of WEST.
b) 3.89 m/s at an angle of 35.0 degrees NORTH of WEST.
c) 3.89 m/s at an angle of 14.0 degrees NORTH of WEST.
d) 2.33 m/s at an angle of 14.0 degrees NORTH of WEST.
e) 2.33 m/s at an angle of 35.0 degrees NORTH of WEST.

18) Chris and Jamie are carrying Wayne on a horizontal stretcher. The uniform stretcher is 2.0 m long and weighs 100 N. Wayne weighs 800 N. Wayne's center of gravity is 75 cm from Chris. Chris and Jamie are at the ends of the stretcher. The force that Jamie is exerting to support the stretcher with Wayne on it, is
a) 250 N
b) 300 N
c) 350 N
d) 400 N
e) 550 N

19) The sound of a jet engine is given as 120 dB. What is the intensity of the jet sound wave,
a) 1.0 W/m^2
b) 0.8 W/m^2
c) 0.6 W/m^2
d) 0.4 W/m^2
e) 0.2 W/m^2

20) The speed of sound in air at 0°C is 331 m/s. What is the velocity of sound in air at a temperature of 30°C?
a) 313 m/s
b) 330 m/s
c) 331 m/s
d) 333 m/s
e) 350 m/s

21) A 30.0 cm long organ pipe is filled with air and is open at one end and closed at the other. The velocity of sound in air at 0°C is 331 m/s. What is the wavelength of the third mode?
a) 48 cm
b) 40 cm
c) 30 cm
d) 24 cm
e) 12 cm

22. A sound source of 100 watts radiates sound uniformly in all directions. The intensity of the sound at a distance of 4.0 m is,

A) 0.250 W/m^2
B) 0.353 W/m^2
C) 0.497 W/m^2
D) 0.535 W/m^2
E) 0.625 W/m^2

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23. A transverse periodic wave is represented by the equation $z(y,t) = 1.5$ cm $\sin(1{,}250$ rad/s $t + 10.0$ m^{-1} $y)$. What is the frequency of the vibration of the wave?

A) 319 Hz
B) 289 Hz
C) 240 Hz
D) 199 Hz
E) 150 Hz

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24. A transverse periodic wave is represented by the equation $y(x,t) = 2.5$ cm $\cos(2{,}500$ rad/s $t - 15.0$ m^{-1} $x)$. What is the direction of the velocity of the wave?

A) The + z direction
B) The + y direction
C) The + x direction
D) The – y direction
E) The – x direction

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25. What is the distance between nodes?

A) wavelength/4
B) wavelength/3
C) wavelength/2
D) wavelength/1

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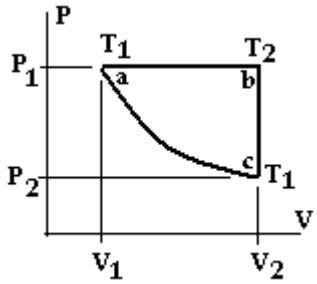
26. A longitudinal wave travels on a slinky or any long spring. The wave is represented by the equation $x(x,t) = 2.1$cm $\cos(2000$ rad/s $t + 40$ m^{-1} $x)$. What is the velocity of the wave?

A) 50 m/s in the + x direction.
B) 50 m/s in the – x direction.
C) 200 m/s in the + x direction.
D) 200 m/s in the – x direction.
E) 2.1 cm/s in the + x direction

27) Two bricks are completely submerged in a tank full of water. Brick 1 is made of lead (denisity = 11,300 kg/m^3) and of size 2cm x 3cm x 5 cm. Brick 2 is made of wood (density = 600 kg/m^3) and of size 3cm x 10cm x 1cm. Which brick has the larger buoyancy force?
a) Brick 1 (lead)
b) Brick 2 (wood)
c) Brick 1 is just a bit larger than brick 2
d) They are the same
e) Depends on the force keeping the wood submerged

28) The specific heat of ice is 2.1 kJ/kg ^oC, the heat of fusion for ice at 0^oC is 333.7 kJ/kg, the specific heat of water 4.186 kJ/kg ^oC, and the heat of vaporization of water at 100 ^oC is 2,256 kJ/ kg. What is the final equilibrium temperature when 30 grams of ice at –15^oC is mixed with 8 grams of steam at 100^oC?
a) 65.6^oC
b) 60.2^oC
c) 56.2^oC
d) 50.1^oC
e) 45.2^oC

USE THIS DIAGRAM FOR THE NEXT TWO QUESTIONS



29) 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

30) 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

31) Which of the following is not included in the internal energy of a system?
a) The net translational kinetic energy of the system.
b) The kinetic energy of the individual particles.
c) The spring potential energy of the individual particles
d) The chemical energy of the individual particles.
e) The nuclear energy of the individual particles.

32) In a neutral object has been charged by friction to a charge of one pC, what has happened to it electrically?
a) 6.25×10^6 electrons have been added to it.
b) 6.25×10^6 protons have been added to it.
c) 6.25×10^6 electrons have been removed from it.
d) 6.25×10^6 protons have been removed from it.
e) 6.25×10^6 electrons and protons have been added to it.

33) When an object is polarized, it
a) must contain more positive charge than negative charge.
b) must contain more negative charge than positive charge.
c) will have a separation of positive and negative charge.
d) must be illuminated by polarized light.
e) must be made of metal.

34) Two point charges are on the x-axis. One charge, $q_1 = 10$ nC, is located at the origin, and the other charge, $q_2 = 18$ nC, is located at $x = 9.0$ m. What is the force on q_2?
a) 20 nN in the positive x-direction
b) 20 pN in the positive x-direction
c) 20 nN in the negative x-direction
d) 20 pN in the negative x-direction
e) 180 nN in the positive x-direction

35) Increasing the distance from a point charge by 34% changes the magnitude of the electric field by what amount?
a) It decreases by 16%.
b) It decreases by 34%.
c) It decreases by 44%.
d) It decreases by 80%.
e) It stays the same!

36) What is the magnitude of the electric field 30 cm from a point charge of 0.35 μC?
a) 1.2×10^{-2} N/C
b) 9.5×10^{-4} N/C
c) 9.5×10^4 N/C
d) 3.5×10^4 N/C
e) 1.1×10^4 N/C

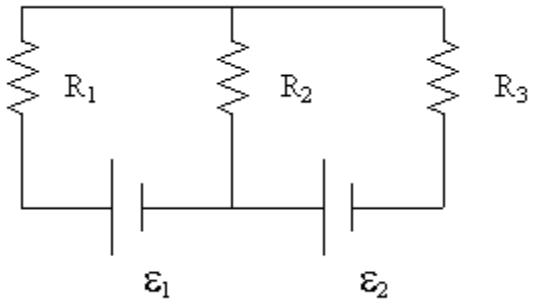
37) If more field lines leave a closed surface than enter that surface, then
a) a net positive charge is contained inside the surface.
b) a net negative charge is contained inside the surface.
c) an error has been made since the number of field lines entering a surface must equal those leaving the surface.
d) an operating electron gun is inside the surface.
e) there must be a charge on the surface.

38) A proton is moving in an electric field. The direction of the acceleration of the proton is
a) in the direction the proton is moving.
b) opposite the direction the proton is moving.
c) perpendicular to the direction the proton is moving.
d) in the direction of the electric field.
e) opposite the direction of the electric field.

39) A hollow conducting sphere of radius 12 cm had a charge of 18 μC placed on it. What is the potential 20 cm from the center of the sphere?
a) 0 V
b) 15 V
c) 73 V
d) 8.1×10^5 V
e) 4.1×10^5 V

40) Which of the following statements is true?
a) Electric field lines stay inside equipotential surfaces.
b) Equipotential surfaces intersect in straight lines.
c) Equipotential surfaces intersect in curved lines.
d) Electric field lines are perpendicular to equipotential surfaces.
e) Equipotential surfaces are parallel to each other.

41) Three resistors, $R_1 = 9\ \Omega$, $R_2 = 3\ \Omega$, and $R_3 = 1\ \Omega$, are connected in parallel to a 9-V battery. What is the power dissipated by the R_2?
a) 117 W
b) 3 W
c) 9 W
d) 27 W
e) 81 W



42) If $R_1 = 6\ \Omega$, $R_2 = 8\ \Omega$, $R_3 = 2\ \Omega$, $\mathcal{E}_1 = 4$ V, and $\mathcal{E}_2 = 14$ V, what is the current in R_2?
a) 1 A
b) 2 A
c) 3 A
d) 4 A
e) 5 A

43) A light ray in air strikes a glass surface with an angle of incidence of 30.0^o. The angle of refraction in the glass is 20.0^o. What is the speed of light in the glass?
a) 3.00×10^8 m/s
b) 2.50×10^8 m/s
c) 2.33×10^8 m/s
d) 2.05×10^8 m/s
e) 1.50 s 10^8 m/s

44) When light in material 1, which is in contact with material 2, undergoes total internal reflection, what condition is necessary for their indices of refraction?
a) $n_1 = 2\ n_2$
b) $n_1 > n_2$
c) $n_1 < n_2$
d) $n_1 = n_2 + 1$
e) $n_2 = 1.5$

45) A 6.0 cm tall object is placed 20 cm in front of a convex mirror with focal –100 cm focal length. Where is the image formed?
a) 80 cm behind the mirror
b) 25 cm behind the mirror
c) 17 cm behind the mirror
d) 17 cm in front of the mirror
e) 25 cm in front of the mirror

46) A thin lens of focal length 12.5 cm has a 5.0-cm tall object placed 10 cm in front of it. Where will the image be formed?
a) 2.5 cm behind the lens
b) 5.6 cm behind the lens
c) 5.6 cm in front of the lens
d) 50 cm behind the lens
e) 50 cm in front of the lens

47) In order to produce an image double the size of an object with a converging lens of focal length f, what object distance should be used?
a) f
b) f/2
c) 2f
d) 2f/3
e) 3f/2

48) According to special relativity, what is the speed of light measured in a space ship traveling at 0.4 c?
a) 0.6 c
b) 1.4 c
c) 0.86 c
d) c
e) none of the above

49) Photons of red light cause a surface to emit photoelectrons with maximum kinetic energy K(red). If photons of blue light of the same intensity are now used in the experiment, which of the following statements is true about the photoelectrons emitted (if any are emitted)?
a) No photoelectrons are emitted.
b) Maximum K(blue) < K(red).
c) Maximum K(blue) = K(red).
d) Maximum K(blue) > K(red).
e) None of the above is true.

50) A particle with non-zero kinetic energy will
a) always have the same wavelength as the same energy photon.
b) always have a greater wavelength than the same energy photon.
c) always have a shorter wavelength than the same energy photon.
d) will sometimes have a greater wavelength than the same energy photon.
e)) will sometimes have a shorter wavelength than the same energy photon.