American Association of Physics Teachers

PHYSICSBOWL 2005

PHYSICS BOWL - APRIL 20, 2005

40 QUESTIONS–45 MINUTES

This contest is sponsored by the **American Association of Physics Teachers**, **Frey Scientific** and **Texas Instruments Incorporated** to generate interest in physics and to recognize outstanding high school physics students and their teachers.

This competition is held in 15 regions, each with two divisions. Division I is for students in a first-year physics course; Division II is for students in an advanced or second-year physics course. A school's score in each division is the sum of the four highest student scores in that division. A school may compete in either or both divisions.

NOTE: one award per student

If your exam is a photocopy or previously opened, your school is in violation of US copyright law and the contest rules.

INSTRUCTIONS

Answer sheet: Write and bubble-in the appropriate information on your answer sheet. You should fill in your name, sex, AAPT School ID Number, and 2 special codes. In the block labeled "IDENTIFICATION NUMBER," write in and encode the 5-digit identification number your teacher will give you. You also need to fill in TWO SPECIAL CODES to identify which level of physics you are taking (column A) and the region you are from (columns F and G). Failure to fill in properly all the above information in your answer sheet will mean your score will not be counted towards the school's team overall score and you will become ineligible for individual recognition. Your answer sheet will be machine graded. Be sure to use a #2 pencil, fill the bubbles completely, and make no stray marks on the answer sheet.

Questions: The test is composed of 50 questions; however, students will be required to answer only 40 questions. Answers should be marked on the answer sheet next to the number corresponding to the number of the question on the test.

Division I students will answer only questions 1-40.

Division II students will answer only questions 11-50. Numbers 1-10 on the answer sheet should remain blank for all Division II students.

Calculator: A hand-held calculator may be used. However, any memory must be cleared of data and programs. Calculators may not be shared.

Formulas and constants: Only the formulas and constants provided with these instructions may be used.

Time limit: 45 minutes.

Score: Your score is equal to the number of correct answers (no deduction for incorrect answers). If there are tie scores, the entries will be compared, from the end of the test forward, until the tie is resolved. Thus, the answers to the last few questions may be important in determining the winner, and you should consider them carefully.

Good Luck!

Do Not Open This Booklet Until You Are Told to Begin.

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You should use the following values in determining the answers on this test. If you use other values in calculating answers, you may obtain values which do not exactly match answer selections found on this test. You will then need to choose the answer on the test closest to your value.

acceleration due to gravity	g	$= 10\ m/s^2$
gravitational constant	G	$= 6.7 \times 10^{-11}\ N \cdot m^2/kg^2$
specific heat of water	c_w	$= 1.0\ kcal/kg \cdot K = 4.2 \times 10^3\ J/kg \cdot K$
atomic mass unit	1 u	$= 1.7 \times 10^{-27}\ kg = 9.3 \times 10^2\ MeV/c^2$
electron volt	1 eV	$= 1.6 \times 10^{-19}\ J$
rest mass of electron	m_e	$= 9.1 \times 10^{-31}\ kg$
rest mass of proton	m_p	$= 1.7 \times 10^{-27}\ kg$
electronic charge	e	$= 1.6 \times 10^{-19}\ C$
Coulomb's constant	k	$= 9.0 \times 10^9\ N \cdot m^2/C^2$
permittivity constant	ε_0	$= 8.9 \times 10^{-12}\ C^2/N \cdot m^2$
permeability constant	μ_0	$= 4\pi \times 10^{-7}\ T \cdot m/A$
speed of sound in air (20˚C)	v_s	$= 340\ m/s$
speed of light in vacuum	c	$= 3.0 \times 10^8\ m/s$
Planck's Constant	h	$= 6.6 \times 10^{-34}\ J \cdot s = 4.14 \times 10^{-15}\ eV \cdot s$
Boltzmann Constant	k	$= 1.38 \times 10^{-23}\ J/K$

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$x = v_0 t + \frac{1}{2}at^2$ $\quad v_f = v_0 + at$ $\quad \bar{v} = \frac{\Delta x}{\Delta t}$

$v_f^2 = v_0^2 + 2a\Delta x$ $\quad v_{0x} = v_0 \cos\theta$ $\quad v_{0y} = v_0 \sin\theta$

$a_c = \frac{v^2}{r}$ $\quad \sum \mathbf{F} = m\mathbf{a}$ $\quad F_g = mg$

$F_g = G\frac{m_1 m_2}{r^2}$ $\quad \mathbf{p} = m\mathbf{v}$ $\quad W = Fs\cos\theta = F_{||}s = Fs_{||}$

$E_k = \frac{1}{2}mv^2$ $\quad E_p = mgh$ $\quad E_p = \frac{1}{2}kx^2$

$P = \frac{W}{\Delta t} = Fv\cos\theta = F_{||}v$ $\quad \tau = RF\sin\theta = RF_{\perp} = R_{\perp}F$ $\quad \sum \tau = I\alpha$

$n = \frac{c}{v}$ $\quad v = f\lambda$ $\quad n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n\lambda = d\frac{x_n}{L} = d\sin\theta_n$ $\quad \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ $\quad m = -\frac{d_i}{d_o}$

$Q = mc\Delta T$ $\quad Q = mL$ $\quad \Delta U = Q - W$

$pV = nRT$ $\quad W = p\Delta V$ $\quad F_e = k\frac{q_1 q_2}{r^2}$

$\mathbf{E} = \frac{\mathbf{F}}{q}$ $\quad V = \frac{W}{q}$ $\quad V = k\frac{q}{r}$

$V = Ed$ $\quad Q = CV$ $\quad V = RI$

$P = VI$ $\quad F = qvB\sin\theta = qvB_{\perp}$ $\quad F = ILB\sin\theta = ILB_{\perp}$

$B = \frac{\mu_0 I}{2\pi r}$ $\quad B = \mu_0 nI$ $\quad emf = BLv$

$E = mc^2$ $\quad E = hf$ $\quad p = \frac{h}{\lambda}$

Nuclear notation: ${}^{A}_{Z}X$ where A is the atomic mass number and Z is the nuclear charge.

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IDENTIFICATION NUMBER

Your teacher will tell you your unique **AAPT School ID Number**. This number can be found on a label attached to the Teacher Packet. This number should be entered in the area marked **IDENTIFICATION NUMBER** on the answer sheet.

SPECIAL CODES

The Special Codes area on the answer form will determine each students Division and Region.

Division: Enter a "1" for Division I (first-year physics students) or a "2" for Division II (advanced physics students) in the Special Code Column "A.

NOTE: There are 50 questions on this year's exam. Division I should answer only questions 1– 40 and leave 41–50 blank while Division II should leave questions 1–10 blank and answer only questions 11–50.

A					F	G
_____	__X___	__X___	___X__	___X__	_____	_____

Region: If you attend a specialized science and math school or if your school finished in first place last year, you must compete in one of the specialized regions, 20 or 21. If not, you may compete in these regions or your regular region Use the following list to find your two digit region code.

02	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
03	New York, Maritime Provinces, Ontario, Quebec
04	New Jersey, Pennsylvania
05	Delaware, District of Columbia, North Carolina, Virginia
06	Florida, Georgia, South Carolina, Puerto Rico, Virgin Islands
07	Kentucky, Maryland, Ohio, West Virginia
08	Illinois, Indiana
09	Iowa, Michigan, Minnesota, Missouri, Wisconsin
10	Alabama, Arkansas, Louisiana, Mississippi, Tennessee
11	Idaho, Montana, Nebraska, North Dakota, South Dakota, Wyoming
12	Arizona, Colorado, Kansas, Nevada, New Mexico, Oklahoma, Texas, Utah
13	California
14	Alaska, American Samoa, Guam, Hawaii, Oregon, Washington, Alberta, British Columbia, Manitoba, Saskatchewan, and others
20	Specialized Science and Math Schools and last years first place schools with ZIP codes 49999 or less or located in provinces Ontario and eastward
21	Specialized Science and Math Schools and last years first place schools with ZIP codes 50000 or greater or located in provinces Manitoba and westward

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ATTENTION: All Division I students, START HERE.
All Division II students, skip the first ten questions, begin on question 11.

1. Which quantity is not a scalar?

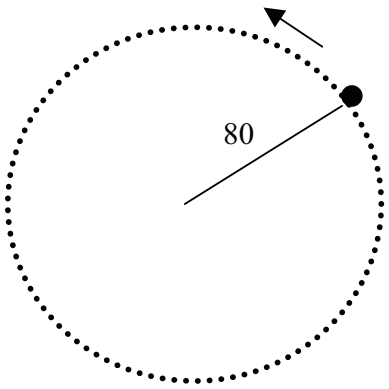
   (a) velocity
   (b) speed
   (c) wavelength
   (d) specific heat
   (e) temperature

2. A pebble is dropped from a high vertical cliff. The collision of the pebble with the ground below is seen 1.50 seconds after the pebble is dropped. With what speed did the pebble hit the ground? Ignore air resistance.

   (a) 10 m/s
   (b) 15 m/s
   (c) 48.6 m/s
   (d) 100.4 m/s
   (e) 343 m/s

3. What is the centripetal acceleration of an object (mass = 50 g) on the end of an 80-cm string rotating at a constant rate of 4 times a second?

   (a) 25 m/s^2
   (b) 32 m/s^2
   (c) 100 m/s^2
   (d) 500 m/s^2
   (e) 2500 m/s^2



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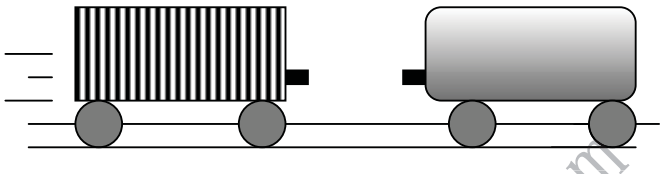
4. A freight car is moving freely along a railroad track at 7.0 m/s and collides with a tanker car that is at rest. After the collision, the two cars stick together and continue to move down the track. What is the magnitude of the final velocity of the cars if the freight car has a mass of 1,200 kg and the tanker car has a mass of 1,600 kg?

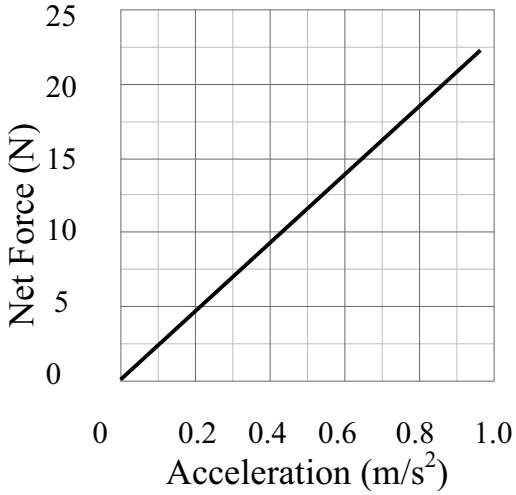
(a) 0.0 m/s
(b) 1.00 m/s
(c) 3.00 m/s
(d) 4.00 m/s
(e) 6.00 m/s



5. A box of old textbooks is on the middle shelf in the bookroom 1.3 m from the floor. If the janitor relocates the box to the shelf that is 2.6 m from the floor, how much work does he do on the box. The box has a mass of 10.0 kg.

(a) 13.0 J
(b) 26.0 J
(c) 52.0 J
(d) 130 J
(e) 260 J

6. The students in a Physics I class were in lab conducting an experiment related to Newton's Second Law. The collected data were displayed on the graph at the right. From this graph, what conclusions can the students make?



(a) The mass of the system was constant.
(b) The acceleration of the system was constant.
(c) The force acting on the system was constant.
(d) The force acting on the system is not related to the acceleration of the system.
(e) The force acting on any system will always be less than 20 N.

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7. A snail is moving along a straight line. Its initial position is x_0 = -5 meters and it is moving away from the origin and slowing down. In this coordinate system, the signs of the initial position, initial velocity and acceleration, respectively, are

Choice	x_0	v_0	a
(a)	-	+	+
(b)	-	-	+
(c)	-	-	-
(d)	-	+	-
(e)	+	+	+

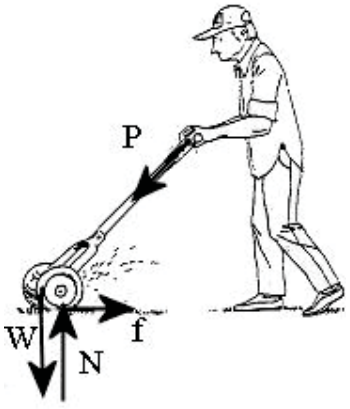
8. Why do raindrops fall with constant speed during the later stages of their descent?

   (a) The gravitational force is the same for all drops.
   (b) All drops fall from the same height.
   (c) The gravitational force is negligible for objects as small as raindrops.
   (d) The gravitational force cannot increase the speed of a falling object to more than 9.8 m/s.
   (e) Air resistance balances the gravitational force on a drop.

9. A tube is open at both ends with the air oscillating in the 4th harmonic. How many displacement nodes are located within the tube?

   (a) 2 (b) 3 (c) 4 (d) 5 (e) 6

10. A homeowner pushes a lawn mower across a horizontal patch of grass with a constant speed by applying a force **P**. The arrows in the diagram correctly indicate the directions but not necessarily the magnitudes of the various forces on the lawn mower. Which of the following relations among the various force magnitudes, *W, f, N, P* is CORRECT?

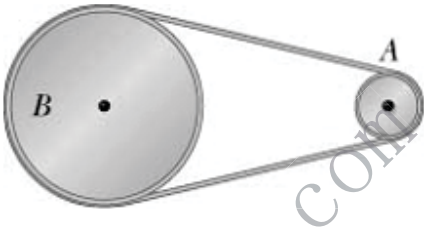


   (a) $P > f$ and $N > W$
   (b) $P < f$ and $N = W$
   (c) $P > f$ and $N < W$
   (d) $P = f$ and $N > W$
   (e) none of the above

ATTENTION: All Division I students, turn page and continue through question 40.

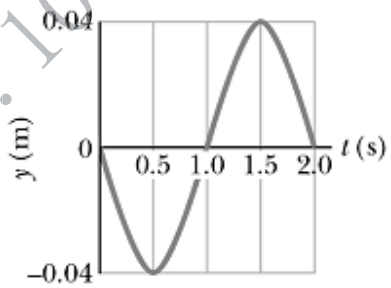
ATTENTION: All Division I students, continue through question 40.
All Division II students, START HERE. Numbers 1-10 on your answer sheet should remain blank. Your first answer should be number 11.

11. A wheel of radius 0.1 m (wheel A) is attached by a non-stretching belt to a wheel of radius 0.2 m (wheel B). The belt does not slip. If wheel B turns through 1 revolution, wheel A will rotate through



(a) ¼ revolution
(b) ½ revolution
(c) 1 revolution
(d) 2 revolutions
(e) 4 revolutions

12. A mass on the end of a spring oscillates with the displacement versus time graph shown to the right. Which of the following statements about its motion is INCORRECT?



(a) The amplitude of the oscillations is 0.08 meters.
(b) The frequency of oscillations is 0.5 Hz.
(c) The mass achieves a maximum in speed at t = 1.0 second.
(d) The period of oscillations is 2.0 seconds.
(e) The mass experiences a maximum in the size of the acceleration at t = 1.5 s.

13. A bat striking a 0.125 kg-baseball is in contact with the ball for a time of 0.03 seconds. The ball travels in a straight line as it approaches and then leaves the bat. If the ball arrives at the bat with a velocity of 4.5 m/s and leaves with a velocity of -6.5 m/s, what is the magnitude of the average force acting on the ball?

(a) 8.33 N
(b) 18.75 N
(c) 27.08 N
(d) 45.83 N
(e) 458 N

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14. An astronaut on the Moon simultaneously drops a feather and a hammer. The fact that they reach the surface at the same instant shows that

(a) no gravity forces act on a body in a vacuum.
(b) the acceleration due to gravity on the Moon is less than the acceleration due to gravity on the Earth.
(c) the gravitational force from the Moon on heavier objects (the hammer) is equal to the gravitational force on lighter objects (the feather).
(d) a hammer and feather have less mass on the Moon than on Earth.
(e) in the absence of air resistance all bodies at a given location fall with the same acceleration.

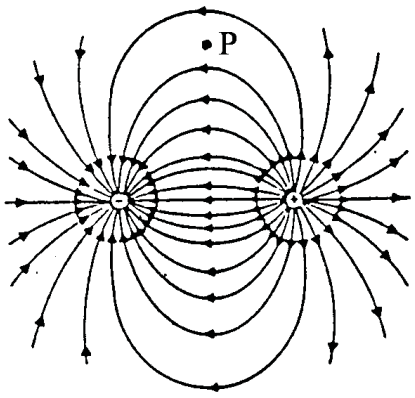
15. In the electromagnetic spectrum, rank the following electromagnetic waves in terms of increasing wavelength

	Smallest wavelength light		Largest wavelength light
(a)	Ultraviolet	X-ray	Radio waves
(b)	Ultraviolet	Radio waves	X-ray
(c)	Radio waves	Ultraviolet	X-ray
(d)	Radio waves	X-ray	Ultraviolet
(e)	X-ray	Ultraviolet	Radio waves

16. A cylindrical graphite resistor has length L and cross-sectional area A. It is to be placed into a circuit, but it first must be cut in half so that the new length is ½ L. What is the ratio of the new resistivity to the old resistivity of the cylindrical resistor?

(a) 4 (b) 2 (c) 1 (d) ½ (e) ¼

17. A small positive test charge is placed at point P in the region near two charges. Which of the following arrows indicates the direction of the force on the positive test charge?

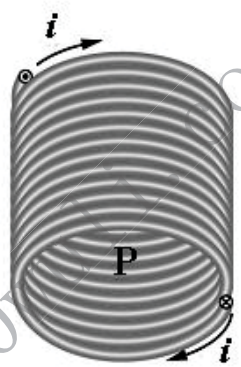


(a) →
(b) ←
(c) ↑
(d) ↓
(e) ↘

18. A student holds a hand mirror to observe the back of her head while standing in front of and looking into a wall mirror. If she is standing 4 ft in front of the wall mirror and she holds the hand mirror 1 ft behind her head, she will see the back of her head how far behind the wall mirror?

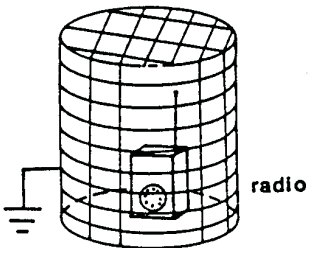
(a) 6 ft (b) 5 ft (c) 4 ft (d) 3 ft (e) 2 ft

19. The magnetic field line passing through point P inside the solenoid shown is directed



(a) to the right.
(b) to the left.
(c) downward the bottom of the page.
(d) upward toward the top of the page.
(e) in no direction since the magnetic field is zero.

20. A portable radio that is playing is placed inside a screen cage as shown. When inside the cage the radio stops playing because

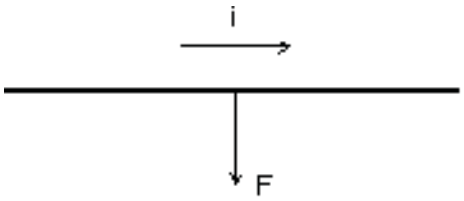


(a) the electric potential of the batteries is neutralized.
(b) the charge on the radio is zero.
(c) the sound cannot travel through the cage.
(d) the electric field of the radio waves cannot penetrate the cage.
(e) none of the above reasons.

21. A household iron used to press clothes is marked "120 volt, 600 watt." In normal use, the current in it is

(a) 0.2 A (b) 2 A (c) 4 A (d) 5 A (e) 7.2 A

22. The diagram below shows a straight wire carrying current *i* in a uniform magnetic field. An arrow indicates the magnetic force F on the wire. Of the following possibilities, the direction of the magnetic field must be



(a) out of the page.
(b) into of the page.
(c) to the right.
(d) up the plane of the page.
(e) down the plane of the page.

23. A person hears a single-frequency sound from a speaker that emits sound uniformly in all directions. The person records the decibel level reading. Which of the following processes would increase the decibel reading the most?

(a) The power output of the speaker is doubled.
(b) The distance of the person to the speaker is halved.
(c) The frequency of the sound is doubled.
(d) The temperature of the air is doubled on the Kelvin scale.
(e) The area over which the sound is transmitted is halved.

24. The hydraulic press, which allows large masses to be lifted with small applied forces, is a consequence of which principle?

(a) Pascal's
(b) Bernoulli's
(c) Archimedes'
(d) Huygens'
(e) Newton's

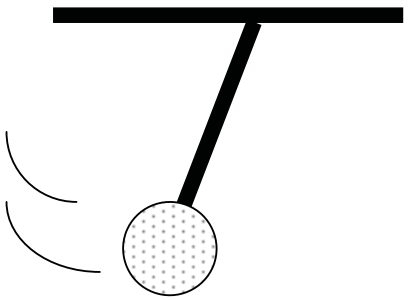
25. A car is seen in ideal white light to be ideal yellow in color. If one were to view this car in ideal blue light, the car would appear to be

(a) yellow (b) red (c) blue (d) green (e) black

26. Light shines from air into a clear material. When the light makes an angle of incidence equal to 30.0^0, the light refracts at an angle of 15.0^0. If the light is shone from an angle of incidence of 60.0^0, what is the angle of refraction?

(a) 19.5^0 (b) 26.6^0 (c) 30.0^0 (d) 45.0^0 (e) 60.0^0

27. What is the period of a simple pendulum if the length of the cord is 67.0 cm and the pendulum bob has a mass of 2.4 kg?



(a) 0.259 s
(b) 1.63 s
(c) 3.86 s
(d) 16.3 s
(e) 24.3 s

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28. A mass, M, is at rest on a frictionless surface, connected to an ideal horizontal spring that is unstretched. A person extends the spring 30 cm from equilibrium and holds it at this location by applying a 10 N force. The spring is brought back to equilibrium and the mass connected to it is now doubled to 2M. If the spring is extended back 30 cm from equilibrium, what is the necessary force applied by the person to hold the mass stationary there?

(a) 20.0 N
(b) 14.1 N
(c) 10.0 N
(d) 7.07 N
(e) 5.00 N

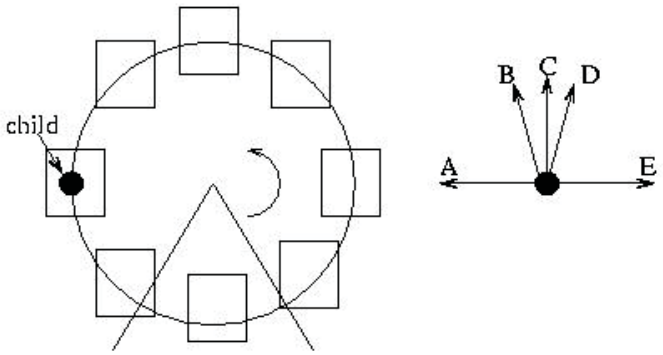
29. An object is in front of a convex lens, at a distance less than the focal length from the lens. Its image is

(a) virtual and larger than the object.
(b) real and smaller than the object.
(c) virtual and smaller than the object.
(d) real and larger than the object.
(e) virtual and the same size as the object.

30. A scientist measures the dimensions of a rectangular solid to be 1.000 mm × 20.00 cm × 5.00 cm. Using proper scientific notation and significant digits, what is the volume of the box in units of m^3?

(a) 1.000×10^{-5}
(b) 1.000×10^{-4}
(c) 1.00×10^{-5}
(d) 1.00×10^{-4}
(e) 1×10^{-5}

31. A child is belted into a Ferris Wheel seat that rotates counterclockwise at constant speed at an amusement park. At the location shown, which direction best represents the total force exerted on the child by the seat and belt?



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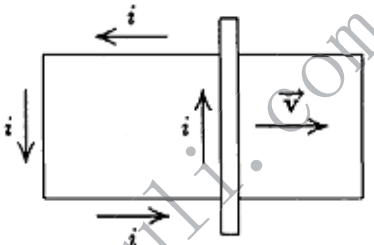
32. A turntable plays a record by spinning at a constant rate of 45 rev/min. What is the average angular acceleration of the record to reach this final angular speed, having started from rest, if it takes 8 seconds to do so? All answers are in units of rad/s^2.

(a) 337.5 (b) 35.34 (c) 5.625 (d) 0.5890 (e) 0.09375

33. The figure below shows a bar moving to the right on two conducting rails. To make an induced current *i* in the direction indicated, in what direction would the magnetic field be in the area contained within the conducting rails?



(a) out of the page
(b) into the page
(c) to the right
(d) to the left
(e) It is impossible to create the current with a constant magnetic field.

34. A 40-kg boy is stationary on a 30-kg plank that is sliding at 5.00 m/s to the right across a frictionless pond. The boy then turns and starts walking on the plank at a rate of 4.00 m/s to the left, relative to the plank. What is the speed of the plank relative to the pond now?

(a) 1.00 m/s (b) 6.08 m/s (c) 7.29 m/s (d) 9.00 m/s (e) 17.00 m/s

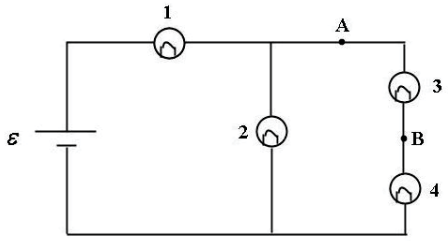
35. An arrow is shot horizontally toward a target 20 m away. In traveling the first 5 m horizontally, the arrow falls 0.2 m. In traveling the next 5 m horizontally it will fall an additional

(a) 0.6 m (b) 0.4 m. (c) 0.3 m (d) 0.2 m (e) 0.1 m

36. When one computes the square root of the ratio of the permeability of free space to the permittivity of free space, one obtains $\sqrt{\frac{\mu_0}{\varepsilon_0}} = 377$. What is the unit of this quantity?

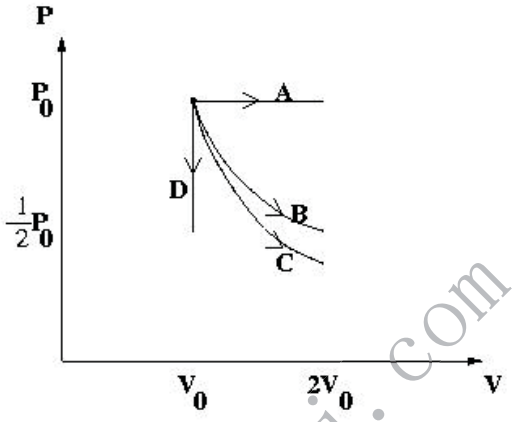
(a) farads (b) joules (c) volts (d) meters per second (e) ohms

37. For the circuit shown, a shorting wire of negligible resistance is added to the circuit between points A and B. When this shorting wire is added, bulb #3 goes out. Which bulbs (all identical) in the circuit brighten?



(a) Only Bulb 2.
(b) Only Bulb 4
(c) Only Bulbs 1 and 4.
(d) Only Bulbs 2 and 4
(e) Bulbs 1,2 ,and 4

38. The PV diagram shows four different possible reversible processes performed on a monatomic ideal gas. Process A is isobaric (constant pressure). Process B is isothermal (constant temperature). Process C is adiabatic. Process D is isochoric (constant volume). For which process(es) does the temperature of the gas decrease?



(a) Process A only
(b) Process C only
(c) Only Processes C and D.
(d) Only Processes B, C, and D
(e) All 4 processes.

39. Muons, unstable elementary particles with lifetimes on the order of a few microseconds, created in the upper levels of the atmosphere are able to reach the surface of the Earth before decaying because

(a) according to observers on Earth, the internal clocks of the muons run faster than for muons at rest.
(b) according to observers on Earth, the muons travel faster than the speed of light.
(c) according to the muons, their lifetime is longer than a few microseconds.
(d) muons last longer in air than in a vacuum
(e) according to the muons, the distance from the upper atmosphere to the surface of the Earth is shorter than that measured by observers on Earth.

40. A new monatomic ideal gas is discovered and named "Physicsbowlium." A pure 4-mole sample is sitting in a container at equilibrium in a 20.0 ^{0}C environment. According to the kinetic theory of gases, what is the average kinetic energy per molecule for this gas?

(a) 4.14×10^{-22} J
(b) 6.07×10^{-21} J
(c) 2.02×10^{-21} J
(d) 3652 J
(e) The molar mass of the gas is needed to answer this question.

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ATTENTION: All Division I students, STOP HERE. Your last answer should be number 40. Numbers 41-50 should remain blank for Division I students.
All Division II students, continue to question 50.

41. In a system of lenses, it is reported that when the calculation of the magnification was performed on a diverging lens that has focal length of magnitude *f*, the image size was identical to that of the object. How is this possible?

(a) The object was virtual and located a distance $2f$ from the lens.
(b) The object was virtual and located a distance f from the lens.
(c) The object was real and located a distance $2f$ from the lens.
(d) The object was real and located a distance f from the lens.
(e) It is not possible.

42. A sample of a monatomic ideal gas starts with pressure, volume, temperature, and number of moles given as P_0, V_0, T_0, n, respectively. The gas has molar specific heats at constant pressure and constant volume of c_p, c_v.

Process 1: The gas is compressed to half of its volume at constant pressure.
Process 2: The gas is expanded isothermally such that the gas does work on the environment equal to the amount of work done onto the gas by the environment during process 1.

What is the entropy change of the gas during Process 2?

(a) $nc_p \ln\left(\frac{1}{2}\right)$
(b) $nc_p (\ln 2)$
(c) $\frac{P_0 V_0}{T_0}$
(d) 0
(e) None of these.

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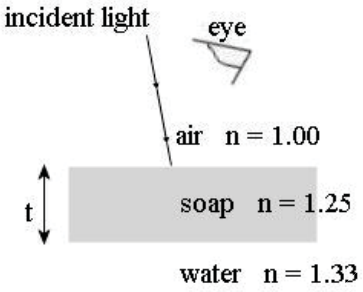
43. Light is incident normal to a thin layer of soap. Given the figure, what is the minimum thickness of the soap film that gives the soap a bluish color (λ = 500 nm)?

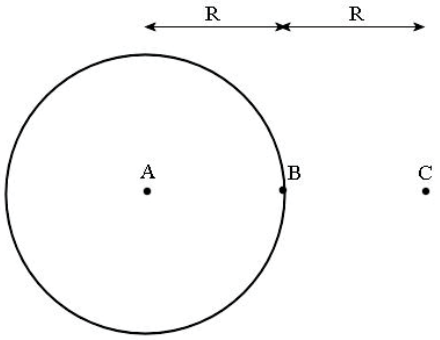


(a) 100 nm
(b) 200 nm
(c) 250 nm
(d) 400 nm
(e) 500 nm

44. A box of mass *m* is initially at rest on a horizontal surface. A constant horizontal force of *mg*/2 is applied to the box, directed to the right. The coefficient of friction of the surface changes with the distance pushed as $\mu = \mu_0 x$ where *x* is the distance from the initial location. For what distance is the box pushed until it returns to rest?

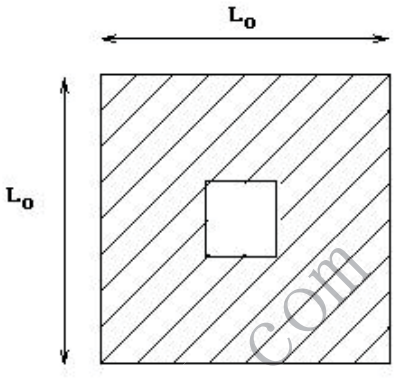
(a) $\frac{4}{\mu_0}$
(b) $\frac{2}{\mu_0}$
(c) $\frac{1}{\mu_0}$
(d) $\frac{1}{2\mu_0}$
(e) $\frac{1}{4\mu_0}$

45. A spherical conducting shell has a net charge $+Q$ placed on it. Which of the following is the correct relationship for the electric potential at the points labeled A, B, and C? Point A is at the center of the sphere, point B is at the surface of the shell, a distance R from point A, and point C is a distance R from point B outside the sphere. As *r* goes to infinity, $V = 0$.



(a) $V_C < V_B < V_A$
(b) $V_A < V_B < V_C$
(c) $V_C = V_B = V_A$
(d) $V_C = V_B < V_A$
(e) $V_C < V_B = V_A$

46. A uniform square piece of metal has initial side length L_0. A square piece is cut out of the center of the metal. The temperature of the metal is now raised so that the side lengths are increased by 4%. What has happened to the area of the square piece cut out of the center of the metal?

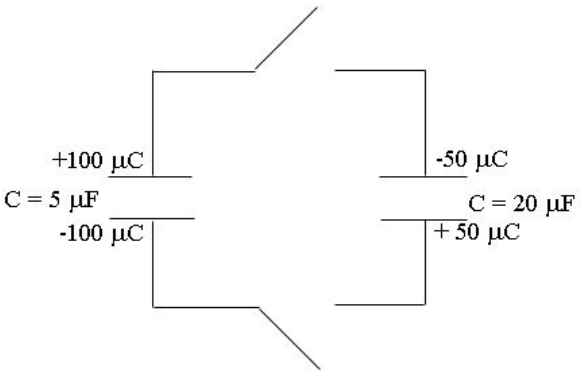


(a) It is increased by 16 %
(b) It is increased by 8 %
(c) It is increased by 4 %
(d) It is decreased by 4 %
(e) It is decreased by 8 %

47. A sound wave generated from a tuning fork of single frequency travels from air (with speed of sound 340 m/s) into rock (with speed of sound 1500 m/s). Which statement is true about the wavelength and frequency of the sound as it passes from air to rock?

(a) The frequency of the sound increases and the wavelength increases.
(b) The frequency of the sound increases and the wavelength is unchanged.
(c) The frequency of the sound is unchanged and the wavelength is decreased.
(d) The frequency of the sound is unchanged and the wavelength is increased.
(e) The frequency of the sound decreases and the wavelength increased.

48. For the configuration of capacitors shown, both switches are closed simultaneously. After equilibrium is established, what is the charge on the top plate of the 5 μF capacitor?



(a) 100 μC
(b) 50 μC
(c) 30 μC
(d) 25 μC
(e) 10 μC

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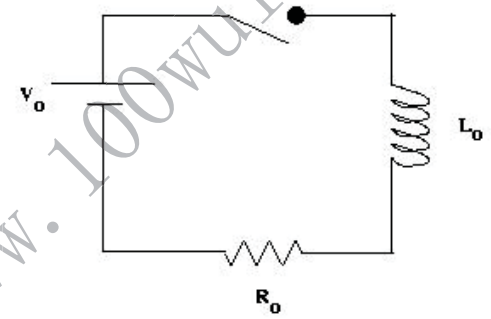
49. Two solid disks are made of the same material. One disk has radius R while the other disk has radius $2R$. Both disks are rotating about a fixed axis perpendicular to the disk, through its center. Given that the disks have equal kinetic energy, what is the ratio of the angular momentum of the disks $\left(L_{2R}/L_R\right)$?

(a) 16
(b) 8
(c) 4
(d) 2
(e) 1

50. A series RL circuit is shown. Which of the suggested changes in the circuit (labeled I, II, and III) would result in the initial voltage across the inductor (at the instant that the switch is closed) to be *double* what it is for the circuit shown?



I. Reduce the resistance in the circuit to $R_0/2$.
II. Double the inductance in the circuit to $2L_0$.
III. Add a second identical inductor to the circuit in parallel with the first inductor.

(a) Only change I
(b) Only change II
(c) Only change III
(d) Changes I and II must be done together
(e) None of the changes achieves the desired result.

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