EVALUATING YOUR PERFORMANCE (GR8677)

Now that you have scored your test, you may wish to compare your performance with the performance of others who took this test. Two kinds of information are provided, both using performance data from GRE Physics examinees tested between October 1981 and September 1984. Interpretive data based on the scores earned by examinees tested in this three-year period were used by admissions officers in 1986-87.

The first kind of information is based on the performance of a sample of the examinees who took the test in October 1985. This sample was selected to represent the total population of GRE Physics examinees tested between October 1981 and September 1984. On the work sheet you used to determine your score is a column labeled "P+." The numbers in this column indicate the percent of the examinees in this sample who answered each question correctly. You may use these numbers as a guide for evaluating your performance on each test question.

Also included, for each scaled score, is the percent of examinees tested between October 1981 and September 1984 who received lower scores. These percents appear in the score conversions table in a column to the right of the scaled scores. For example, in the percent column opposite the scaled score of 660 is the percent 57. This means that 57 percent of the Physics examinees tested between October 1981 and September 1984 scored lower than 660. To compare yourself with this population, look at the percent next to the scaled score you earned on the practice test. This number is a reasonable indication of your rank among GRE Physics Test examinees if you followed the test-taking suggestions in this practice book.

It is important to realize that the conditions under which you tested yourself were not exactly the same as those you will encounter at a test center. It is impossible to predict how different test-taking conditions will affect test performance, and this is only one factor that may account for differences between your practice test scores and your actual test scores. By comparing your performance on this practice test with the performance of other GRE Physics Test examinees, however, you will be able to determine your strengths and weaknesses and can then plan a program of study to prepare yourself for taking the Physics Test under standard conditions.

Before you start timing yourself on the test that follows, we suggest that you remove an answer sheet (pages 151 to 156) and turn first to the back cover of the test book (page 37), as you will do at the test center, and follow the instructions for completing the identification areas of the answer sheet. When you are ready to begin the test, note the time and start marking your answers to the questions on the answer sheet.

FORM GR8677

77

THE GRADUATE RECORD EXAMINATIONS

PHYSICS TEST

Do not break the seal until you are told to do so.

The contents of this test are confidential. Disclosure or reproduction of any portion of it is prohibited.

TABLE OF INFORMATION

Rest mass of the electron	$m_e = 9.11 \times 10^{-31}$ kilogram $= 9.11 \times 10^{-28}$ gram
Magnitude of the electron charge	$e = 1.60 \times 10^{-19}$ coulomb $= 4.80 \times 10^{-10}$ statcoulomb (esu)
Avogadro's number	$N_0 = 6.02 \times 10^{23}$ per mole
Universal gas constant	$R = 8.32$ joules/(mole · K)
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ joule/K $= 1.38 \times 10^{-16}$ erg/K
Speed of light	$c = 3.00 \times 10^8$ m/s $= 3.00 \times 10^{10}$ cm/s
Planck's constant	$h = 6.63 \times 10^{-34}$ joule · second $= 4.14 \times 10^{-15}$ eV · second
Vacuum permittivity	$\epsilon_0 = 8.85 \times 10^{-12}$ coulomb²/(newton · meter²)
Vacuum permeability	$\mu_0 = 4\pi \times 10^{-7}$ weber/(ampere · meter)
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ meter³/(kilogram · second²)
Acceleration due to gravity	$g = 9.80$ m/s² $= 980$ cm/s²
1 atmosphere pressure	1 atm $= 1.0 \times 10^5$ newton/meter² $= 1.0 \times 10^5$ pascals (Pa)
1 ångstrom	1 Å $= 1 \times 10^{-10}$ meter

1 weber/m² = 1 tesla = 10^4 gauss

PHYSICS TEST

Time—170 minutes

100 Questions

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then blacken the corresponding space on the answer sheet.

1. A rock is thrown vertically upward with initial speed v_0. Assume a friction force proportional to $-\mathbf{v}$, where $\mathbf{v}$ is the velocity of the rock, and neglect the buoyant force exerted by air. Which of the following is correct?

   (A) The acceleration of the rock is always equal to $\mathbf{g}$.
   (B) The acceleration of the rock is equal to $\mathbf{g}$ only at the top of the flight.
   (C) The acceleration of the rock is always less than $\mathbf{g}$.
   (D) The speed of the rock upon return to its starting point is v_0.
   (E) The rock can attain a terminal speed greater than v_0 before it returns to its starting point.

2. A satellite orbits the Earth in a circular orbit. An astronaut on board perturbs the orbit slightly by briefly firing a control jet aimed toward the Earth's center. Afterward, which of the following is true of the satellite's path?

   (A) It is an ellipse.
   (B) It is a hyperbola.
   (C) It is a circle with larger radius.
   (D) It is a spiral with increasing radius.
   (E) It exhibits many radial oscillations per revolution.

3. For blue light, a transparent material has a relative permittivity (dielectric constant) of 2.1 and a relative permeability of 1.0. If the speed of light in a vacuum is c, the phase velocity of blue light in an unbounded medium of this material is

   (A) $\sqrt{3.1}\,c$

   (B) $\sqrt{2.1}\,c$

   (C) $\dfrac{c}{\sqrt{1.1}}$

   (D) $\dfrac{c}{\sqrt{2.1}}$

   (E) $\dfrac{c}{\sqrt{3.1}}$

4. The equation $y = A \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$, where A, T, and λ are positive constants, represents a wave whose

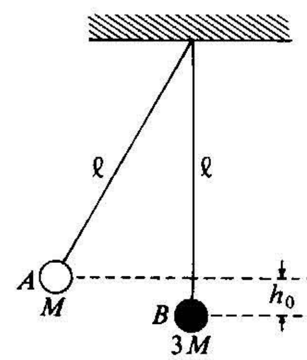
   (A) amplitude is $2A$

   (B) velocity is in the negative x-direction

   (C) period is $\frac{T}{\lambda}$

   (D) speed is $\frac{x}{t}$

   (E) speed is $\frac{\lambda}{T}$



5. Two small spheres of putty, A and B, of mass M and $3M$, respectively, hang from the ceiling on strings of equal length ℓ. Sphere A is drawn aside so that it is raised to a height h_0 as shown above and then released. Sphere A collides with sphere B; they stick together and swing to a maximum height h equal to

   (A) $\frac{1}{16}h_0$ (B) $\frac{1}{8}h_0$ (C) $\frac{1}{4}h_0$

   (D) $\frac{1}{3}h_0$ (E) $\frac{1}{2}h_0$

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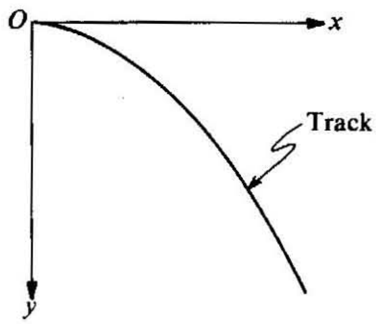


6. A particle is initially at rest at the top of a curved frictionless track. The x- and y-coordinates of the track are related in dimensionless units by $y = \frac{x^2}{4}$, where the positive y-axis is in the vertical downward direction. As the particle slides down the track, what is its tangential acceleration?

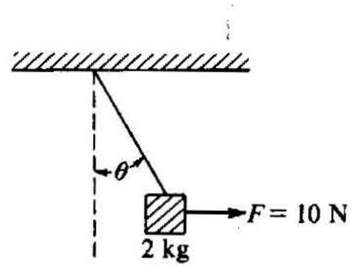
(A) 0

(B) g

(C) $\frac{gx}{2}$

(D) $\frac{gx}{\sqrt{x^2 + 4}}$

(E) $\frac{gx^2}{\sqrt{x^2 + 16}}$



7. A 2-kilogram box hangs by a massless rope from a ceiling. A force slowly pulls the box horizontally to the side until the horizontal force is 10 newtons. The box is then in equilibrium as shown above. The angle that the rope makes with the vertical is closest to

(A) arctan 0.5
(B) arcsin 0.5
(C) arctan 2.0
(D) arcsin 2.0
(E) 45°

8. A 5-kilogram stone is dropped on a nail and drives the nail 0.025 meter into a piece of wood. If the stone is moving at 10 meters per second when it hits the nail, the average force exerted on the nail by the stone while the nail is going into the wood is most nearly

(A) 10 N
(B) 100 N
(C) 1000 N
(D) 10,000 N
(E) 100,000 N

9. A wire of diameter 0.02 meter contains 1×10^{28} free electrons per cubic meter. For an electric current of 100 amperes, the drift velocity for free electrons in the wire is most nearly

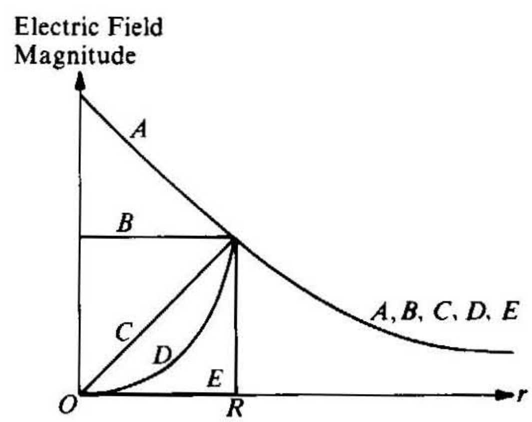
(A) 0.6×10^{-29} m/s

(B) 1×10^{-19} m/s

(C) 5×10^{-10} m/s

(D) 2×10^{-4} m/s

(E) 8×10^{3} m/s



10. An isolated sphere of radius R contains a uniform volume distribution of positive charge. Which of the curves on the graph above correctly illustrates the dependence of the magnitude of the electric field of the sphere as a function of the distance r from its center?

(A) A (B) B (C) C (D) D (E) E

GO ON TO THE NEXT PAGE.

11. Which of the following equations is a consequence of the equation $\nabla \times \mathbf{H} = \dot{\mathbf{D}} + \mathbf{J}$?

(A) $\nabla \cdot (\dot{\mathbf{D}} + \mathbf{J}) = 0$

(B) $\nabla \times (\dot{\mathbf{D}} + \mathbf{J}) = 0$

(C) $\nabla (\dot{\mathbf{D}} \cdot \mathbf{J}) = 0$

(D) $\dot{\mathbf{D}} + \mathbf{J} = 0$

(E) $\dot{\mathbf{D}} \cdot \mathbf{J} = 0$

12. A source of 1-kilohertz sound is moving straight toward you at a speed 0.9 times the speed of sound. The frequency you receive is

(A) 0.1 kHz
(B) 0.5 kHz
(C) 1.1 kHz
(D) 1.9 kHz
(E) 10 kHz

13. Two coherent sources of visible monochromatic light form an interference pattern on a screen. If the relative phase of the sources is varied from 0 to 2π at a frequency of 500 hertz, which of the following best describes the effect, if any, on the interference pattern?

(A) It is unaffected because the frequency of the phase change is very small compared to the frequency of visible light.
(B) It is unaffected because the frequency of the phase change is an integral multiple of π.
(C) It is destroyed except when the phase difference is 0 or π.
(D) It is destroyed for all phase differences because the monochromaticity of the sources is destroyed.
(E) It is not destroyed but simply shifts positions at a rate too rapid to be detected by the eye.

14. For an ideal gas, the specific heat at constant pressure C_p is greater than the specific heat at constant volume C_v because the

(A) gas does work on its environment when its pressure remains constant while its temperature is increased
(B) heat input per degree increase in temperature is the same in processes for which either the pressure or the volume is kept constant
(C) pressure of the gas remains constant when its temperature remains constant
(D) increase in the gas's internal energy is greater when the pressure remains constant than when the volume remains constant
(E) heat needed is greater when the volume remains constant than when the pressure remains constant

15. A sample of N atoms of helium gas is confined in a 1.0 cubic meter volume. The probability that none of the helium atoms is in a 1.0×10^{-6} cubic meter volume of the container is

(A) 0 (B) $(10^{-6})^N$ (C) $(1 - 10^{-6})^N$
(D) $1 - (10^{-6})^N$ (E) 1

16. Except for mass, the properties of the muon most closely resemble the properties of the

(A) electron (B) graviton (C) photon
(D) pion (E) proton

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17. Suppose that ${}^{A}_{Z}X$ decays by natural radioactivity in two stages to ${}^{A-4}_{Z-1}Y$. The two stages would most likely be which of the following?

	First Stage	Second Stage
(A)	β^- emission with an antineutrino	α emission
(B)	β^- emission	α emission with a neutrino
(C)	β^- emission	γ emission
(D)	Emission of a deuteron	Emission of two neutrons
(E)	α emission	γ emission

18. The wave function $\psi(x) = A \exp\left\{-\frac{b^2x^2}{2}\right\}$, where A and b are real constants, is a normalized eigenfunction of the Schrödinger equation for a particle of mass M and energy E in a one dimensional potential $V(x)$ such that $V(x) = 0$ at $x = 0$. Which of the following is correct?

(A) $V = \frac{\hbar^2 b^4}{2M}$

(B) $V = \frac{\hbar^2 b^4 x^2}{2M}$

(C) $V = \frac{\hbar^2 b^6 x^4}{2M}$

(D) $E = \hbar^2 b^2(1 - b^2x^2)$

(E) $E = \frac{\hbar^2 b^4}{2M}$

19. The energy levels of the hydrogen atom are given in terms of the principal quantum number n and a positive constant A by the expression

(A) $A\left(n + \frac{1}{2}\right)$

(B) $A(1 - n^2)$

(C) $A\left(-\frac{1}{4} + \frac{1}{n^2}\right)$

(D) $A\,n^2$

(E) $-\frac{A}{n^2}$

20. A positive kaon (K^+) has a rest mass of 494 MeV/c^2, whereas a proton has a rest mass of 938 MeV/c^2. If a kaon has a total energy that is equal to the proton rest energy, the speed of the kaon is most nearly

(A) 0.25 c
(B) 0.40 c
(C) 0.55 c
(D) 0.70 c
(E) 0.85 c

21. Two observers O and O' observe two events, A and B. The observers have a constant relative speed of 0.8 c. In units such that the speed of light is 1, observer O obtained the following coordinates:

Event A: $x = 3,\ y = 3,\ z = 3,\ t = 3$
Event B: $x = 5,\ y = 3,\ z = 1,\ t = 5$

What is the length of the space-time interval between these two events, as measured by O'?

(A) 1 (B) $\sqrt{2}$ (C) 2 (D) 3 (E) $2\sqrt{3}$

22. Which of the following statements most accurately describes how an electromagnetic field behaves under a Lorentz transformation?

(A) The electric field transforms completely into a magnetic field.
(B) If initially there is only an electric field, after the transformation there may be both an electric and a magnetic field.
(C) The electric field is unaltered.
(D) The magnetic field is unaltered.
(E) It cannot be determined unless a gauge transformation is also specified.

23. Which of the following statements concerning the electrical conductivities at room temperature of a pure copper sample and a pure silicon sample is NOT true?

(A) The conductivity of the copper sample is many orders of magnitude greater than that of the silicon sample.
(B) If the temperature of the copper sample is increased, its conductivity will decrease.
(C) If the temperature of the silicon sample is increased, its conductivity will increase.
(D) The addition of an impurity in the copper sample always decreases its conductivity.
(E) The addition of an impurity in the silicon sample always decreases its conductivity.

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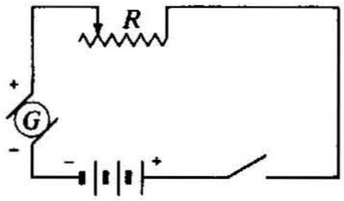

100 V, 1 Ω

24. The battery in the diagram above is to be charged by the generator G. The generator has a terminal voltage of 120 volts when the charging current is 10 amperes. The battery has an emf of 100 volts and an internal resistance of 1 ohm. In order to charge the battery at 10 amperes charging current, the resistance R should be set at

(A) 0.1 Ω (B) 0.5 Ω (C) 1.0 Ω
(D) 5.0 Ω (E) 10.0 Ω

25. A charged particle is released from rest in a region where there is a constant electric field and a constant magnetic field. If the two fields are parallel to each other, the path of the particle is a

(A) circle
(B) parabola
(C) helix
(D) cycloid
(E) straight line

26. A nickel target ($Z = 28$) is bombarded with fast electrons. The minimum electron kinetic energy needed to produce x-rays in the K series is most nearly

(A) 10 eV
(B) 100 eV
(C) 1000 eV
(D) 10,000 eV
(E) 100,000 eV

27. The hypothesis that an electron possesses spin is qualitatively significant for the explanation of all of the following topics EXCEPT the

(A) structure of the periodic table
(B) specific heat of metals
(C) anomalous Zeeman effect
(D) deflection of a moving electron by a uniform magnetic field
(E) fine structure of atomic spectra

28. Eigenfunctions for a rigid dumbbell rotating about its center have a ϕ dependence of the form $\psi(\phi) = Ae^{im\phi}$, where m is a quantum number and A is a constant. Which of the following values of A will properly normalize the eigenfunction?

(A) $\sqrt{2\pi}$

(B) 2π

(C) $(2\pi)^2$

(D) $\frac{1}{\sqrt{2\pi}}$

(E) $\frac{1}{2\pi}$

29. A negative test charge is moving near a long straight wire in which there is a current. A force will act on the test charge in a direction parallel to the direction of the current if the motion of the charge is in a direction

(A) toward the wire
(B) away from the wire
(C) the same as that of the current
(D) opposite to that of the current
(E) perpendicular to both the direction of the current and the direction toward the wire

30. The configuration of the potassium atom in its ground state is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$. Which of the following statements about potassium is true?

(A) Its $n = 3$ shell is completely filled.
(B) Its $4s$ subshell is completely filled.
(C) Its least tightly bound electron has $\ell = 4$.
(D) Its atomic number is 17.
(E) Its electron charge distribution is spherically symmetrical.

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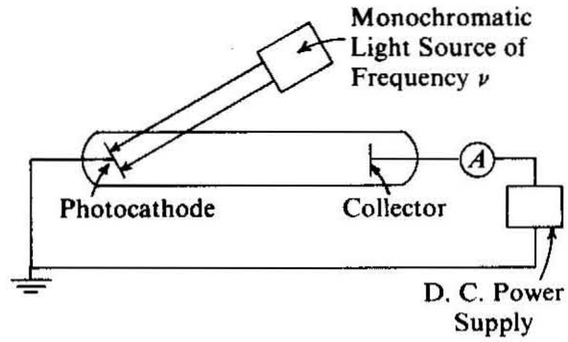
Questions 31-33 refer to the following apparatus used to study the photoelectric effect.



In this apparatus, the photocathode and the collector are made from the same material. The potential V of the collector, measured relative to ground, is initially zero and is then increased or decreased monotonically. The effect is described by Einstein's photoelectric equation

$$|eV| = h\nu - W.$$

31. When the photoelectric equation is satisfied and applicable to this situation, V is the

(A) negative value at which the current stops
(B) negative value at which the current starts
(C) positive value at which the current stops
(D) positive value at which the current starts
(E) voltage induced when the light is on

32. The photoelectric equation is derived under the assumption that

(A) electrons are restricted to orbits of angular momentum $n\hbar$, where n is an integer
(B) electrons are associated with waves of wavelength $\lambda = h/p$, where p is momentum
(C) light is emitted only when electrons jump between orbits
(D) light is absorbed in quanta of energy $E = h\nu$
(E) light behaves like a wave

33. The quantity W in the photoelectric equation is the

(A) energy difference between the two lowest electron orbits in the atoms of the photocathode
(B) total light energy absorbed by the photocathode during the measurement
(C) minimum energy a photon must have in order to be absorbed by the photocathode
(D) minimum energy required to free an electron from its binding to the cathode material
(E) average energy of all electrons in the photocathode

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Questions 34-36

The potential energy of a body constrained to move on a straight line is kx^4 where k is a constant. The position of the body is x, its speed v, its linear momentum p, and its mass m.

34. The force on the body is

(A) $\frac{1}{2}mv^2$ (B) $-4kx^3$ (C) kx^4

(D) $-\frac{kx^5}{5}$ (E) mg

35. The Hamiltonian function for this system is

(A) $\frac{p^2}{2m} + kx^4$ (B) $\frac{p^2}{2m} - kx^4$ (C) kx^4

(D) $\frac{1}{2}mv^2 - kx^4$ (E) $\frac{1}{2}mv^2$

36. The body moves from x_1 at time t_1 to x_2 at time t_2. Which of the following quantities is an extremum for the $x - t$ curve corresponding to this motion, if end points are fixed?

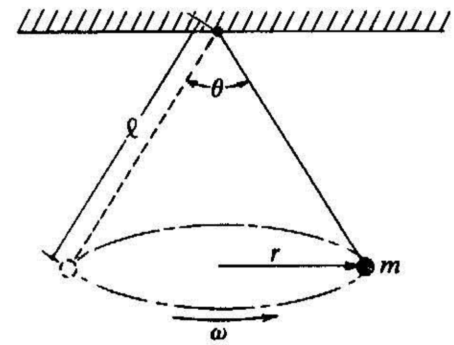
(A) $\int_{t_1}^{t_2} \left(\frac{1}{2}mv^2 - kx^4\right) dt$

(B) $\int_{t_1}^{t_2} \left(\frac{1}{2}mv^2\right) dt$

(C) $\int_{t_1}^{t_2} (mxv) dt$

(D) $\int_{x_1}^{x_2} \left(\frac{1}{2}mv^2 + kx^4\right) dx$

(E) $\int_{x_1}^{x_2} (mv) dx$



37. The figure above represents a point mass m attached to the ceiling by a cord of fixed length ℓ. If the point mass moves in a horizontal circle of radius r with uniform angular velocity ω, the tension in the cord is

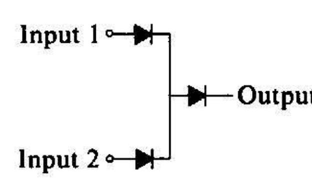
(A) $mg\left(\frac{r}{\ell}\right)$

(B) $mg \cos\left(\frac{\theta}{2}\right)$

(C) $\frac{m\omega r}{\sin\left(\frac{\theta}{2}\right)}$

(D) $m(\omega^2 r^2 + g^2)^{\frac{1}{2}}$

(E) $m(\omega^4 r^2 + g^2)^{\frac{1}{2}}$



38. If logical 0 is 0 volts and logical 1 is +1 volt, the circuit shown above is a logic circuit commonly known as

(A) an OR gate
(B) an AND gate
(C) a 2-bit adder
(D) a flip-flop
(E) a fanout

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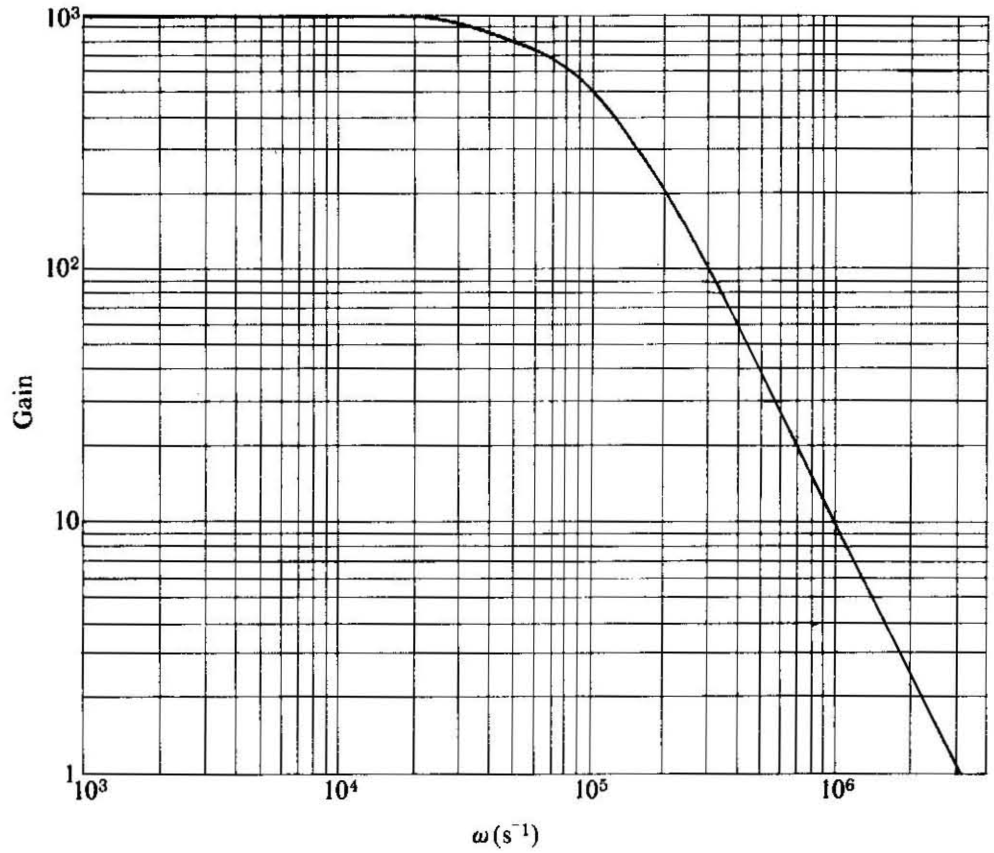

39. The gain of an amplifier is plotted *versus* angular frequency ω in the diagram above. If K and a are positive constants, the frequency dependence of the gain near $\omega = 3 \times 10^5$ second^{-1} is most accurately expressed by

(A) $Ke^{-a\omega}$ (B) $K\omega^2$ (C) $K\omega$ (D) $K\omega^{-1}$ (E) $K\omega^{-2}$

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40. An experimenter measures 9934 counts during one hour from a radioactive sample. From this number the counting rate of the sample can be estimated with a standard deviation of most nearly

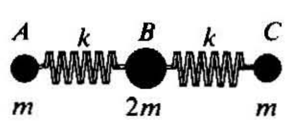
(A) 100 (B) 200 (C) 300
(D) 400 (E) 500

41. Which of the following nuclei has the largest binding energy per nucleon? (Consider the most abundant isotope of each element.)

(A) Helium
(B) Carbon
(C) Iron
(D) Uranium
(E) Plutonium

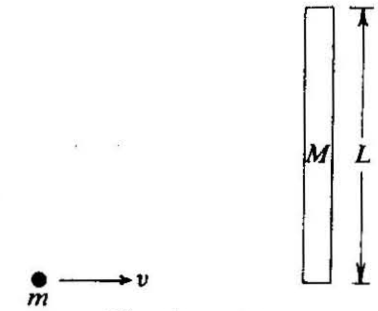
42. A proton beam is incident on a scatterer 0.1 centimeter thick. The scatterer contains 10^{20} target nuclei per cubic centimeter. In passing through the scatterer, one proton per incident million is scattered. The scattering cross section is

(A) 10^{-29} cm^2
(B) 10^{-27} cm^2
(C) 10^{-25} cm^2
(D) 10^{-23} cm^2
(E) 10^{-21} cm^2



43. Three masses are connected by two springs as shown above. A longitudinal normal mode with frequency $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ is exhibited by

(A) A, B, C all moving in the same direction with equal amplitude
(B) A and C moving in opposite directions with equal amplitude, and B at rest
(C) A and C moving in the same direction with equal amplitude, and B moving in the opposite direction with the same amplitude
(D) A and C moving in the same direction with equal amplitude, and B moving in the opposite direction with twice the amplitude
(E) none of the above



View from Above

44. A uniform stick of length L and mass M lies on a frictionless horizontal surface. A point particle of mass m approaches the stick with speed v on a straight line perpendicular to the stick that intersects the stick at one end, as shown above. After the collision, which is elastic, the particle is at rest. The speed V of the center of mass of the stick after the collision is

(A) $\frac{m}{M}v$ (B) $\frac{m}{M+m}v$ (C) $\sqrt{\frac{m}{M}}v$

(D) $\sqrt{\frac{m}{M+m}}v$ (E) $\frac{3m}{M}v$

45. Photons of wavelength λ scatter elastically on free protons initially at rest. The wavelength of the photons scattered at 90° is increased by

(A) $\lambda/137$
(B) $\lambda/1836$
(C) h/m_ec, where h is Planck's constant, m_e the rest mass of an electron, and c the speed of light
(D) h/m_pc, where h is Planck's constant, m_p the rest mass of a proton, and c the speed of light
(E) zero

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46. A blackbody at temperature T_1 radiates energy at a power level of 10 milliwatts (mW). The same blackbody, when at a temperature $2T_1$, radiates energy at a power level of

(A) 10 mW (B) 20 mW (C) 40 mW
(D) 80 mW (E) 160 mW

47. The Franck-Hertz experiment and related scattering experiments show that

(A) electrons are always scattered elastically from atoms
(B) electrons are never scattered elastically from atoms
(C) electrons of a certain energy range can be scattered inelastically, and the energy lost by electrons is discrete
(D) electrons always lose the same energy when they are scattered inelastically
(E) there is no energy range in which the energy lost by electrons varies continuously

48. A transition in which one photon is radiated by the electron in a hydrogen atom when the electron's wave function changes from ψ_1 to ψ_2 is forbidden if ψ_1 and ψ_2

(A) have opposite parity
(B) are orthogonal to each other
(C) are zero at the center of the atomic nucleus
(D) are both spherically symmetrical
(E) are associated with different angular momenta

49. The Hamiltonian operator in the Schrödinger equation can be formed from the classical Hamiltonian by substituting

(A) wavelength and frequency for momentum and energy
(B) a differential operator for momentum
(C) transition probability for potential energy
(D) sums over discrete eigenvalues for integrals over continuous variables
(E) Gaussian distributions of observables for exact values

50. The Hall effect is used in solid-state physics to measure

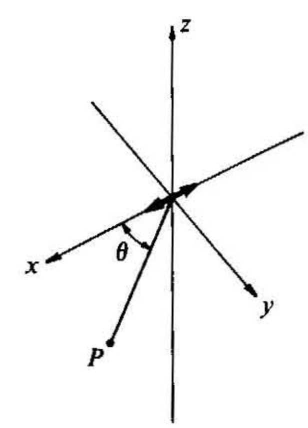
(A) ratio of charge to mass
(B) magnetic susceptibility
(C) the sign of the charge carriers
(D) the width of the gap between the conduction and valence bands
(E) Fermi energy

51. One feature common to both the Debye theory and the Einstein theory of the specific heat of a crystal composed of N identical atoms is that the

(A) average energy of each atom is $3kT$
(B) vibrational energy of the crystal is equivalent to the energy of $3N$ independent harmonic oscillators
(C) crystal is assumed to be continuous for all elastic waves
(D) speed of the longitudinal elastic waves is less than the speed of the transverse elastic waves
(E) upper cutoff frequency of the elastic waves is the same

52. A cube has a constant electric potential V on its surface. If there are no charges inside the cube, the potential at the center of the cube is

(A) zero (B) $V/8$ (C) $V/6$
(D) $V/2$ (E) V



53. A charged particle oscillates harmonically along the x-axis as shown above. The radiation from the particle is detected at a distant point P, which lies in the xy-plane. The electric field at P is in the

(A) $\pm z$ direction and has a maximum amplitude at $\theta = 90°$
(B) $\pm z$ direction and has a minimum amplitude at $\theta = 90°$
(C) xy-plane and has a maximum amplitude at $\theta = 90°$
(D) xy-plane and has a minimum amplitude at $\theta = 90°$
(E) xy-plane and has a maximum amplitude at $\theta = 45°$

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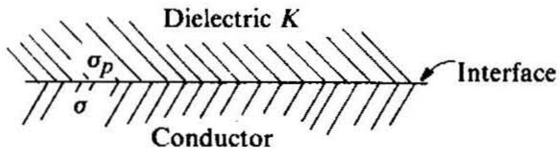

54. A dielectric of dielectric constant K is placed in contact with a conductor having surface charge density σ, as shown above. What is the polarization (bound) charge density σ_p on the surface of the dielectric at the interface between the two materials?

(A) $\sigma\frac{K}{1-K}$ (B) $\sigma\frac{K}{1+K}$ (C) σK

(D) $\sigma\frac{1+K}{K}$ (E) $\sigma\frac{1-K}{K}$

55. The mean kinetic energy of electrons in metals at room temperature is usually many times the thermal energy kT. Which of the following can best be used to explain this fact?

(A) The energy-time uncertainty relation
(B) The Pauli exclusion principle
(C) The degeneracy of the energy levels
(D) The Born approximation
(E) The wave-particle duality

56. If ψ is a normalized solution of the Schrödinger equation and Q is the operator corresponding to a physical observable x, the quantity $\psi^* Q \psi$ may be integrated in order to obtain the

(A) normalization constant for ψ
(B) spatial overlap of Q with ψ
(C) mean value of x
(D) uncertainty in x
(E) time derivative of x

57. Which of the following is an eigenfunction of the linear momentum operator $-i\hbar\frac{\partial}{\partial x}$ with a positive eigenvalue $\hbar k$; i.e., an eigenfunction that describes a particle that is moving in free space in the direction of positive x with a precise value of linear momentum?

(A) $\cos kx$ (B) $\sin kx$ (C) e^{-ikx}

(D) e^{ikx} (E) e^{-kx}

58. In an ordinary hologram, coherent monochromatic light produces a 3-dimensional picture because wave information is recorded for which of the following?

I. Amplitude
II. Phase
III. Wave-front angular frequency

(A) I only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

59. The dispersion law for a certain type of wave motion is $\omega = (c^2k^2 + m^2)^{\frac{1}{2}}$, where ω is the angular frequency, k is the magnitude of the propagation vector, and c and m are constants. The group velocity of these waves approaches

(A) infinity as $k \to 0$ and zero as $k \to \infty$
(B) infinity as $k \to 0$ and c as $k \to \infty$
(C) c as $k \to 0$ and zero as $k \to \infty$
(D) zero as $k \to 0$ and infinity as $k \to \infty$
(E) zero as $k \to 0$ and c as $k \to \infty$

60. A particle of mass m that moves along the x-axis has potential energy $V(x) = a + bx^2$, where a and b are positive constants. Its initial velocity is v_0 at $x = 0$. It will execute simple harmonic motion with a frequency determined by the value of

(A) b alone
(B) b and a alone
(C) b and m alone
(D) b, a, and m alone
(E) b, a, m, and v_0

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Questions 61-62

The equation of motion of a rocket in free space can be written

$$m\frac{dv}{dt} + u\frac{dm}{dt} = 0$$

where m is the rocket's mass, v is its velocity, t is time, and u is a constant.

61. The constant u represents the speed of the
(A) rocket at $t = 0$
(B) rocket after its fuel is spent
(C) rocket in its instantaneous rest frame
(D) rocket's exhaust in a stationary frame
(E) rocket's exhaust relative to the rocket

62. The equation can be solved to give v as a function of m. If the rocket has $m = m_0$ and $v = 0$ when it starts, what is the solution?
(A) $u\, m_0/m$
(B) $u \exp(m_0/m)$
(C) $u \sin(m_0/m)$
(D) $u \tan(m_0/m)$
(E) None of the above.

---

63. A point charge $-q$ coulombs is placed at a distance d from a large grounded conducting plane. The surface charge density on the plane a distance D from the point charge is

(A) $\frac{q}{4\pi D}$

(B) $\frac{qD^2}{2\pi}$

(C) $\frac{qd}{2\pi D^2}$

(D) $\frac{qd}{2\pi D^3}$

(E) $\frac{qd}{4\pi\epsilon_0 D^2}$

64. An alternating current electrical generator has a fixed internal impedance $R_g + jX_g$ and is used to supply power to a passive load that has an impedance $R_g + jX_\ell$, where $j = \sqrt{-1}$, $R_g \neq 0$, and $X_g \neq 0$. For maximum power transfer between the generator and the load, X_ℓ should be equal to

(A) 0 (B) X_g (C) $-X_g$

(D) R_g (E) $-R_g$

65. A current i in a circular loop of radius b produces a magnetic field. At a fixed point far from the loop, the strength of the magnetic field is proportional to which of the following combinations of i and b?

(A) ib (B) ib^2 (C) i^2b (D) $\frac{i}{b}$ (E) $\frac{i}{b^2}$

66. For a system in which the number of particles is fixed, the reciprocal of the Kelvin temperature T is given by which of the following derivatives? (Let P = pressure, V = volume, S = entropy, and U = internal energy.)

(A) $\left(\frac{\partial P}{\partial V}\right)_S$

(B) $\left(\frac{\partial P}{\partial S}\right)_V$

(C) $\left(\frac{\partial S}{\partial P}\right)_U$

(D) $\left(\frac{\partial V}{\partial P}\right)_U$

(E) $\left(\frac{\partial S}{\partial U}\right)_V$

67. A large isolated system of N weakly interacting particles is in thermal equilibrium. Each particle has only 3 possible nondegenerate states of energies 0, ϵ, and 3ϵ. When the system is at an absolute temperature $T >> \epsilon/k$, where k is Boltzmann's constant, the average energy of each particle is

(A) 0 (B) ϵ (C) $\frac{4}{3}\epsilon$ (D) 2ϵ (E) 3ϵ

68. If a newly discovered particle X moves with a speed equal to the speed of light in vacuum, then which of the following must be true?
(A) The rest mass of X is zero.
(B) The spin of X equals the spin of a photon.
(C) The charge of X is carried on its surface.
(D) X does not spin.
(E) X cannot be detected.

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Questions 69-71

A car of rest length 5 meters passes through a garage of rest length 4 meters. Due to the relativistic Lorentz contraction, the car is only 3 meters long in the garage's rest frame. There are doors on both ends of the garage, which open automatically when the front of the car reaches them and close automatically when the rear passes them. The opening or closing of each door requires a negligible amount of time.

69. The velocity of the car in the garage's rest frame is

(A) 0.4 c
(B) 0.6 c
(C) 0.8 c
(D) greater than c
(E) not determinable from the data given

70. The length of the garage in the car's rest frame is

(A) 2.4 m
(B) 4.0 m
(C) 5.0 m
(D) 8.3 m
(E) not determinable from the data given

71. Which of the following statements is the best response to the question:

"Was the car ever inside a closed garage?"

(A) No, because the car is longer than the garage in all reference frames.
(B) No, because the Lorentz contraction is not a "real" effect.
(C) Yes, because the car is shorter than the garage in all reference frames.
(D) Yes, because the answer to the question in the garage's rest frame must apply in all reference frames.
(E) There is no unique answer to the question, as the order of door openings and closings depends on the reference frame.

72. The measured index of refraction of x-rays in rock salt is less than one. This is consistent with the theory of relativity because

(A) relativity deals with light waves traveling in a vacuum only
(B) x-rays cannot transmit signals
(C) x-ray photons have imaginary mass
(D) the theory of relativity predates the development of solid-state physics
(E) the phase velocity and group velocity are different

73. It is necessary to coat a glass lens with a non-reflecting layer. If the wavelength of the light in the coating is λ, the best choice is a layer of material having an index of refraction between those of glass and air and a thickness of

(A) $\frac{\lambda}{4}$ (B) $\frac{\lambda}{2}$ (C) $\frac{\lambda}{\sqrt{2}}$ (D) λ (E) 1.5λ

74. Unpolarized light is incident on two ideal polarizers in series. The polarizers are oriented so that no light emerges through the second polarizer. A third polarizer is now inserted between the first two and its orientation direction is continuously rotated through 180°. The maximum fraction of the incident power transmitted through all three polarizers is

(A) zero (B) $\frac{1}{8}$ (C) $\frac{1}{2}$ (D) $\frac{1}{\sqrt{2}}$ (E) 1

75. The period of a hypothetical Earth satellite orbiting at sea level would be 80 minutes. In terms of the Earth's radius R_e, the radius of a synchronous satellite orbit (period 24 hours) is most nearly

(A) 3 R_e
(B) 7 R_e
(C) 18 R_e
(D) 320 R_e
(E) 5800 R_e

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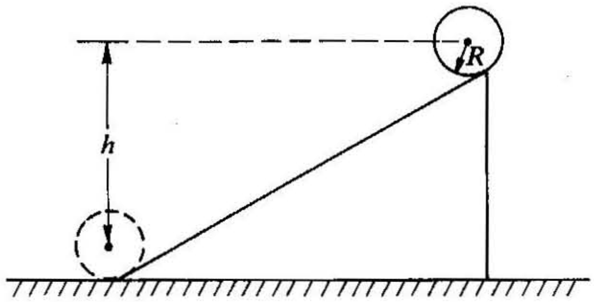


76. A hoop of mass M and radius R is at rest at the top of an inclined plane as shown above. The hoop rolls down the plane without slipping. When the hoop reaches the bottom, its angular momentum around its center of mass is

(A) $MR\sqrt{gh}$

(B) $\frac{1}{2}MR\sqrt{gh}$

(C) $M\sqrt{2gh}$

(D) Mgh

(E) $\frac{1}{2}Mgh$

77. A particle is constrained to move along the x-axis under the influence of the net force $\mathbf{F} = -k\mathbf{x}$ with amplitude A and frequency f, where k is a positive constant. When $x = A/2$, the particle's speed is

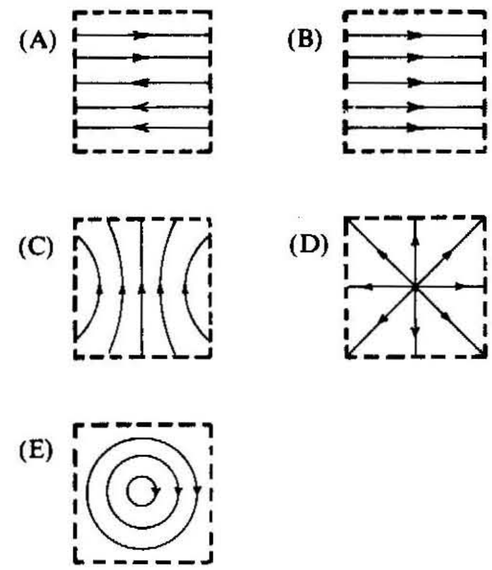
(A) $2\pi fA$ (B) $\sqrt{3}\pi fA$ (C) $\sqrt{2}\pi fA$

(D) πfA (E) $\frac{1}{3}\pi fA$

78. A system consists of two charged particles of equal mass. Initially the particles are far apart, have zero potential energy, and one particle has nonzero speed. If radiation is neglected, which of the following is true of the total energy of the system?

(A) It is zero and remains zero.
(B) It is negative and constant.
(C) It is positive and constant.
(D) It is constant, but the sign cannot be determined unless the initial velocities of both particles are known.
(E) It cannot be a constant of the motion because the particles exert force on each other.

79. One of Maxwell's equations is $\nabla \cdot \mathbf{B} = 0$. Which of the following sketches shows magnetic field lines that clearly violate this equation within the region bounded by the dashed lines?



80. Which of the following electric fields could exist in a finite region of space that contains no charges? (In these expressions, A is a constant, and $\mathbf{i}$, $\mathbf{j}$, and $\mathbf{k}$ are unit vectors pointing in the x, y, and z directions, respectively.)

(A) $A(2xy\mathbf{i} - xz\mathbf{k})$
(B) $A(-xy\mathbf{j} + xz\mathbf{k})$
(C) $A(xz\mathbf{i} + xz\mathbf{j})$
(D) $Axyz(\mathbf{i} + \mathbf{j})$
(E) $Axyz\mathbf{i}$

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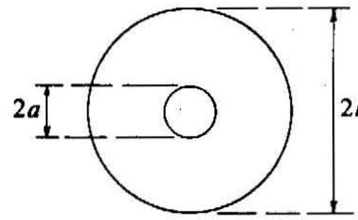


81. A small circular wire loop of radius a is located at the center of a much larger circular wire loop of radius b as shown above. The larger loop carries an alternating current $I = I_0 \cos \omega t$, where I_0 and ω are constants. The magnetic field generated by the current in the large loop induces in the small loop an emf that is approximately equal to which of the following? (Either use mks units and let μ_0 be the permeability of free space, or use Gaussian units and let μ_0 be $4\pi/c^2$.)

(A) $\left(\frac{\pi\mu_0 I_0}{2}\right)\frac{a^2}{b}\omega \cos \omega t$

(B) $\left(\frac{\pi\mu_0 I_0}{2}\right)\frac{a^2}{b}\omega \sin \omega t$

(C) $\left(\frac{\pi\mu_0 I_0}{2}\right)\frac{a}{b^2}\omega \sin \omega t$

(D) $\left(\frac{\pi\mu_0 I_0}{2}\right)\frac{a}{b^2} \cos \omega t$

(E) $\left(\frac{\pi\mu_0 I_0}{2}\right)\frac{a}{b} \sin \omega t$

82. The emission spectrum of an atomic gas in a magnetic field differs from that of the gas in the absence of a magnetic field. Which of the following is true of the phenomenon?

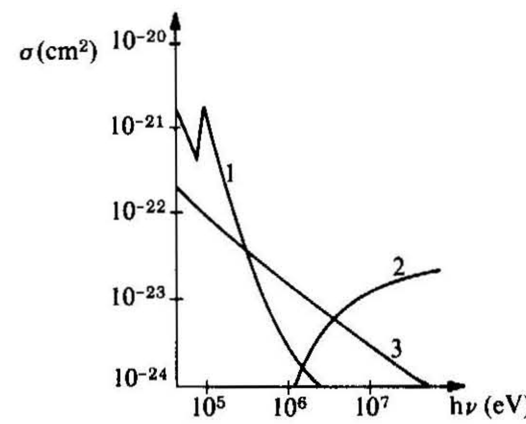
(A) It is called the Stern-Gerlach effect.
(B) It is called the Stark effect.
(C) It is due primarily to the nuclear magnetic moment of the atoms.
(D) The number of emission lines observed for the gas in a magnetic field is always twice the number observed in the absence of a magnetic field.
(E) The number of emission lines observed for the gas in a magnetic field is either greater than or equal to the number observed in the absence of a magnetic field.

83. A spectral line is produced by a gas that is sufficiently dense that the mean time between atomic collisions is much shorter than the mean lives of the atomic states responsible for the line. Compared with the same line produced by a low-density gas, the line produced by the higher-density gas will appear

(A) the same
(B) more highly polarized
(C) broader
(D) shifted toward the blue end of the spectrum
(E) split into a doublet

84. Sodium has eleven electrons and the sequence in which energy levels fill in atoms is $1s$, $2s$, $2p$, $3s$, $3p$, $4s$, $3d$, etc. What is the ground state of sodium in the usual notation ${}^{2S+1}L_J$?

(A) ${}^1S_0$ (B) ${}^2S_{\frac{1}{2}}$ (C) ${}^1P_0$
(D) ${}^2P_{\frac{1}{2}}$ (E) ${}^3P_{\frac{1}{2}}$



85. The figure above shows the photon interaction cross sections for lead in the energy range where the Compton, photoelectric, and pair production processes all play a role. What is the correct identification of these cross sections?

(A) 1 = photoelectric, 2 = Compton, 3 = pair production
(B) 1 = photoelectric, 2 = pair production, 3 = Compton
(C) 1 = Compton, 2 = pair production, 3 = photoelectric
(D) 1 = Compton, 2 = photoelectric, 3 = pair production
(E) 1 = pair production, 2 = photoelectric, 3 = Compton

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86. The exponent in Coulomb's inverse square law has been found to differ from two by less than one part in a billion by measuring which of the following?

(A) The charge on an oil drop in the Millikan experiment
(B) The deflection of an electron beam in an electric field
(C) The neutrality of charge of an atom
(D) The electric force between two charged objects
(E) The electric field inside a charged conducting shell

87. In a gas of N diatomic molecules, two possible models for a classical description of a diatomic molecule are:

Model I | Model II

Rigid Dumbbell | Springy Dumbbell

Which of the following statements about this gas is true?

(A) Model I has a specific heat $c_v = \frac{3}{2}Nk$.
(B) Model II has a smaller specific heat than Model I.
(C) Model I is always correct.
(D) Model II is always correct.
(E) The choice between Models I and II depends on the temperature.

88. Consider a system of N noninteracting particles confined in a volume V at a temperature such that the particles obey classical Boltzmann statistics. If the temperature is lowered to the point at which quantum effects become important, the pressure of the gas may differ depending on whether the particles are fermions or bosons. Let P_F be the pressure exerted by the particles if they are fermions, P_B be the pressure if they are bosons, and P_C be the pressure the particles would exert if quantum effects are ignored. Which of the following is true?

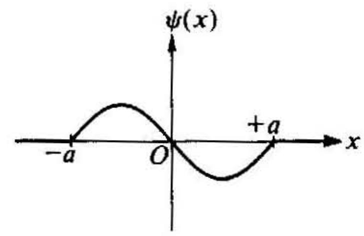
(A) $P_F = P_B = P_C$
(B) $P_F > P_C > P_B$
(C) $P_F > P_B > P_C$
(D) $P_F < P_B < P_C$
(E) $P_F < P_C < P_B$

89. A system containing two identical particles is described by a wave function of the form

$$\psi = \frac{1}{\sqrt{2}}[\psi_\alpha(x_1)\,\psi_\beta(x_2) + \psi_\beta(x_1)\,\psi_\alpha(x_2)]$$

where x_1 and x_2 represent the spatial coordinates of the particles and α and β represent all the quantum numbers, including spin, of the states that they occupy. The particles might be

(A) electrons
(B) positrons
(C) protons
(D) neutrons
(E) deuterons



90. The figure above shows one of the possible energy eigenfunctions $\psi(x)$ for a particle bouncing freely back and forth along the x-axis between impenetrable walls located at $x = -a$ and $x = +a$. The potential energy equals zero for $|x| < a$. If the energy of the particle is 2 electron volts when it is in the quantum state associated with this eigenfunction, what is its energy when it is in the quantum state of lowest possible energy?

(A) 0 eV (B) $\frac{1}{\sqrt{2}}$ eV (C) $\frac{1}{2}$ eV
(D) 1 eV (E) 2 eV

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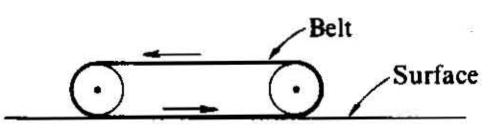
91. When a narrow beam of monoenergetic electrons impinges on the surface of a single metal crystal at an angle of 30 degrees with the plane of the surface, first-order reflection is observed. If the spacing of the reflecting crystal planes is known from x-ray measurements to be 3 ångstroms, the speed of the electrons is most nearly

(A) 1.4×10^{-4} m/s
(B) 2.4 m/s
(C) 5.0×10^{3} m/s
(D) 2.4×10^{6} m/s
(E) 4.5×10^{9} m/s

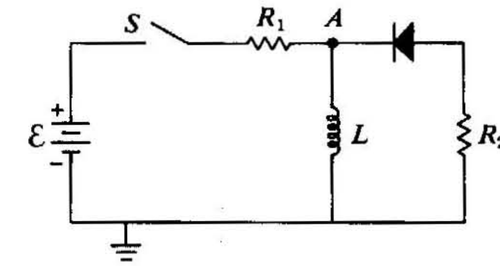
92. Which of the following is NOT compatible with the selection rule that controls electric dipole emission of photons by excited states of atoms?

(A) Δn may have any negative integral value.
(B) $\Delta \ell = \pm 1$
(C) $\Delta m_{\ell} = 0, \pm 1$
(D) $\Delta s = \pm 1$
(E) $\Delta j = \pm 1$

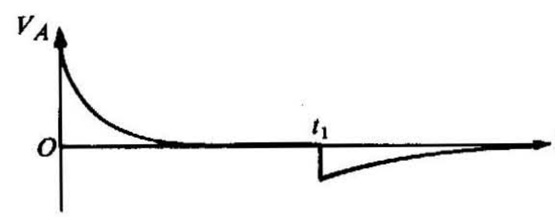


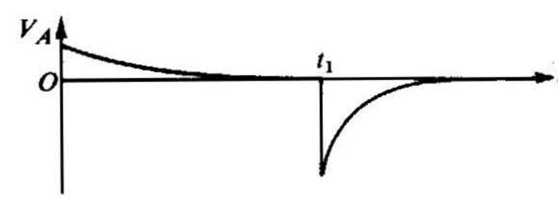
93. An electric sander has a continuous belt that rubs against a wood surface as shown schematically above. The sander is 100 percent efficient and draws a current of 9 amperes from a 120-volt line. The belt speed is 10 meters per second. If the sander is pushing against the wood with a normal force of 100 newtons, the coefficient of friction is most nearly

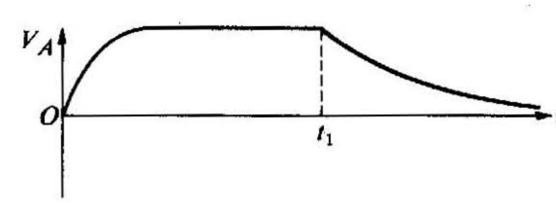
(A) 0.02 (B) 0.2 (C) 0.4
(D) 1.1 (E) 10

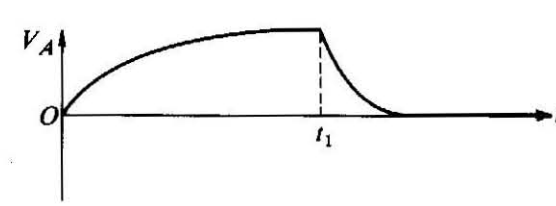


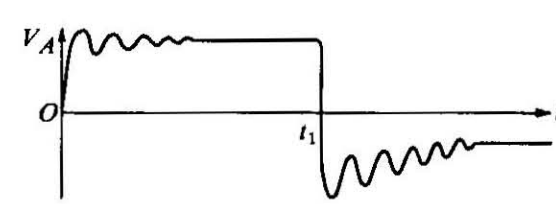
94. In the circuit shown above, $R_2 = 3R_1$ and the battery of emf $\mathcal{E}$ has negligible internal resistance. The resistance of the diode when it allows current to pass through it is also negligible. At time $t = 0$, the switch S is closed and the currents and voltages are allowed to reach their asymptotic values. Then at time t_1, the switch is opened. Which of the following curves most nearly represents the potential at point A as a function of time t?

(A)


(B)


(C)


(D)


(E)


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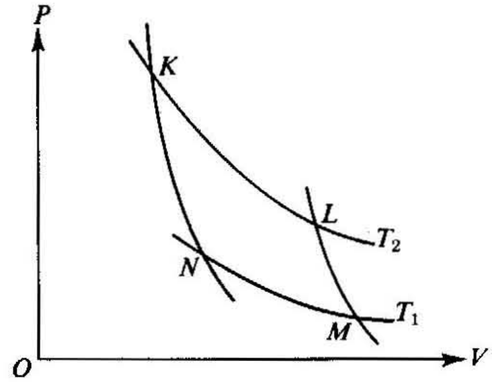

95. In the cycle shown above, KL and NM represent isotherms, while KN and LM represent reversible adiabats. A system is carried through the Carnot cycle $KLMN$, taking in heat Q_2 from the hot reservoir T_2 and releasing heat Q_1 to the cold reservoir T_1. All of the following statements are true EXCEPT:

(A) $Q_1/T_1 = Q_2/T_2$.
(B) The entropy of the hot reservoir decreases.
(C) The entropy of the system increases.
(D) The work W done is equal to the net heat absorbed, $Q_2 - Q_1$.
(E) The efficiency of the cycle is independent of the working substance.

96. A particle of mass M is in an infinitely deep square well potential V where

$$V = 0 \quad \text{for } -a \leqq x \leqq a, \text{ and}$$
$$V = \infty \quad \text{for } x < -a, a < x.$$

A very small perturbing potential V' is superimposed on V such that

$$V' = \epsilon\left(\frac{a}{2} - |x|\right) \quad \text{for } \frac{-a}{2} \leqq x \leqq \frac{a}{2}, \text{ and}$$
$$V' = 0 \quad \text{for } x < \frac{-a}{2}, \frac{a}{2} < x.$$

If $\psi_0, \psi_1, \psi_2, \psi_3, \ldots$ are the energy eigenfunctions for a particle in the infinitely deep square well potential, with ψ_0 being the ground state, which of the following statements is correct about the eigenfunction ψ_0' of a particle in the perturbed potential $V + V'$?

(A) $\psi_0' = a_{00}\psi_0,\ a_{00} \neq 0$

(B) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} = 0$ for all odd values of n

(C) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} = 0$ for all even values of n

(D) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} \neq 0$ for all values of n

(E) None of the above

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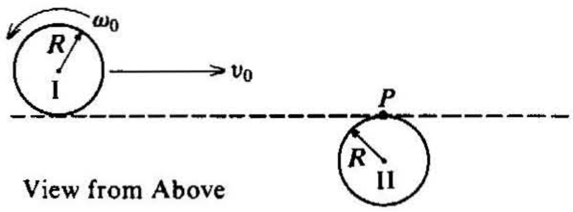


97. Two uniform cylindrical disks of identical mass M, radius R, and moment of inertia $\frac{1}{2} MR^2$, as shown above, collide on a frictionless, horizontal surface. Disk I, having an initial counterclockwise angular velocity ω_0 and a center-of-mass velocity $v_0 = \frac{1}{2} \omega_0 R$ to the right, makes a grazing collision with disk II initially at rest. If after the collision the two disks stick together, the magnitude of the total angular momentum about the point P is

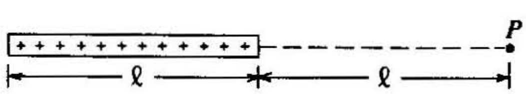
(A) zero

(B) $\frac{1}{2} MR^2 \omega_0$

(C) $\frac{1}{2} MRv_0$

(D) MRv_0

(E) dependent on the time of the collision



98. The long thin cylindrical glass rod shown above has length ℓ and is insulated from its surroundings. The rod has an excess charge Q uniformly distributed along its length. Assume the electric potential to be zero at infinite distances from the rod. If k is the constant in Coulomb's law, the electric potential at a point P along the axis of the rod and a distance ℓ from one end is $\frac{kQ}{\ell}$ multiplied by

(A) $\frac{4}{9}$

(B) $\frac{1}{2}$

(C) $\frac{2}{3}$

(D) $\ln 2$

(E) 1

99. The positronium "atom" consists of an electron and a positron bound together by their mutual Coulomb attraction and moving about their center of mass, which is located halfway between them. Thus the positronium "atom" is somewhat analogous to a hydrogen atom. The ground-state binding energy of hydrogen is 13.6 electron volts. What is the ground-state binding energy of positronium?

(A) $\left(\frac{1}{2}\right)^2 \times 13.6$ eV

(B) $\frac{1}{2} \times 13.6$ eV

(C) 13.6 eV

(D) 2×13.6 eV

(E) $(2)^2 \times 13.6$ eV

100. The screen of a pinhole camera is at a distance D from the pinhole, which has a diameter d. The light has an effective wavelength λ. ($\lambda << D$) For which of the following values of d will the image be sharpest?

(A) $\sqrt{\lambda D}$ (B) λ (C) $\frac{\lambda}{10}$

(D) $\frac{\lambda^2}{D}$ (E) $\frac{D^2}{\lambda}$

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS TEST.

WORK SHEET for the PHYSICS Test, Form GR8677
Answer Key and Percentages* of Examinees Answering Each Question Correctly

QUESTION Number	Answer	P+	TOTAL C	TOTAL I
1	B	67		
2	A	51		
3	D	55		
4	E	55		
5	A	19		
6	D	39		
7	A	75		
8	D	47		
9	D	39		
10	C	58		
11	A	60		
12	E	39		
13	E	52		
14	A	42		
15	C	36		
16	A	48		
17	A	32		
18	B	30		
19	E	64		
20	E	37		
21	C	24		
22	B	58		
23	E	55		
24	C	55		
25	E	57		
26	D	28		
27	D	39		
28	D	71		
29	A	38		
30	E	35		
31	A	34		
32	D	90		
33	D	89		
34	B	86		
35	A	73		

Correct (C) ____________

Incorrect (I) ____________

QUESTION Number	Answer	P+	TOTAL C	TOTAL I
36	A	41		
37	E	55		
38	A	53		
39	E	20		
40	A	42		
41	C	34		
42	C	38		
43	B	66		
44	A	42		
45	D	41		
46	E	67		
47	C	46		
48	D	21		
49	B	74		
50	C	51		
51	B	30		
52	E	46		
53	C	36		
54	E	16		
55	B	33		
56	C	79		
57	D	59		
58	B	45		
59	E	41		
60	C	67		
61	E	55		
62	E	62		
63	D	34		
64	C	22		
65	B	33		
66	E	44		
67	C	34		
68	A	89		
69	C	72		
70	A	66		

Correct (C) ____________

Incorrect (I) ____________

QUESTION Number	Answer	P+	TOTAL C	TOTAL I
71	E	65		
72	E	63		
73	A	38		
74	B	30		
75	B	30		
76	A	38		
77	B	34		
78	C	57		
79	D	77		
80	B	51		
81	B	30		
82	E	39		
83	C	45		
84	B	35		
85	B	22		
86	E	23		
87	E	57		
88	B	26		
89	E	31		
90	C	40		
91	D	30		
92	D	20		
93	D	41		
94	B	14		
95	C	31		
96	B	23		
97	A	17		
98	D	46		
99	B	25		
100	A	36		

Correct (C) ____________

Incorrect (I) ____________

Total Score:

C – I/4 = ____________

Scaled Score (SS) = ____________

*Estimated P+ for the group of examinees who took the GRE Physics Test in a recent three year period.

SCORE CONVERSIONS AND PERCENTS BELOW*
FOR GRE PHYSICS TEST, Form GR8677

TOTAL SCORE					
Raw Score	Scaled Score	%	Raw Score	Scaled Score	%
84-100	990	98	39	650	54
83	980	98	37-38	640	52
81-82	970	98	36	630	48
80	960	97	35	620	46
79	950	97	33-34	610	43
77-78	940	97	32	600	41
76	930	96	30-31	590	38
75	920	96	29	580	35
73-74	910	95	28	570	32
72	900	95	26-27	560	30
71	890	94	25	550	27
69-70	880	93	24	540	25
68	870	92	22-23	530	22
67	860	92	21	520	20
65-66	850	91	20	510	18
64	840	90	18-19	500	16
63	830	89	17	490	14
61-62	820	87	16	480	12
60	810	86	14-15	470	10
59	800	85	13	460	9
57-58	790	84	12	450	8
56	780	82	10-11	440	6
55	770	80	9	430	5
53-54	760	78	8	420	4
52	750	77	6-7	410	3
51	740	75	5	400	2
49-50	730	72	4	390	1
48	720	70	2-3	380	1
47	710	69	1	370	1
45-46	700	66	0	360	0
44	690	64			
43	680	62			
41-42	670	59			
40	660	57			

*Percent scoring below the scaled score based on the performance of the 10,625 examinees who took the GRE Subject Test in Physics between October 1, 1981, and September 30, 1984.