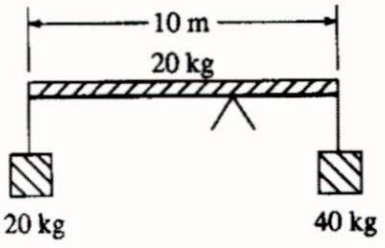
GRE PHYSICS DIAGNOSTIC TEST

Time – 50 minutes
27 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 circle your answer.

1. A ball is dropped from a height h. As it bounces off the floor, its speed is 80 percent of what it was just before it hit the floor. The ball will then rise to a height of most nearly

(A) 0.94 h
(B) 0.80 h
(C) 0.75 h
(D) 0.64 h
(E) 0.50 h

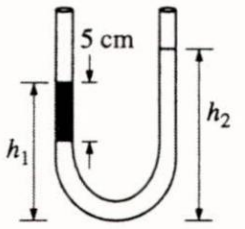


2. A uniform rod of length 10 meters and mass 20 kilograms is balanced on a fulcrum with a 40-kilogram mass on one end of the rod and a 20-kilogram mass on the other end, as shown above. How far is the fulcrum located from the center of the rod?

(A) 0 m
(B) 1 m
(C) 1.25 m
(D) 1.5 m
(E) 2 m

3. When it is about the same distance from the Sun as is Jupiter, a spacecraft on a mission to the outer planets has a speed that is 1.5 times the speed of Jupiter in its orbit. Which of the following describes the orbit of the spacecraft about the Sun?

(A) Spiral
(B) Circle
(C) Ellipse
(D) Parabola
(E) Hyperbola

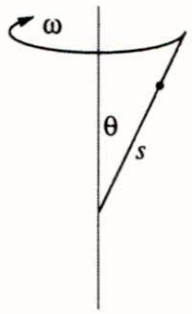


4. An open-ended U-tube of uniform cross-sectional area contains water (density 1.0 gram/centimeter^3) standing initially 20 centimeters from the bottom in each arm. An immiscible liquid of density 4.0 grams/centimeter^3 is added to one arm until a layer 5 centimeters high forms, as shown in the figure above. What is the ratio h_2/h_1 of the heights of the liquid in the two arms?

(A) 3/1
(B) 5/2
(C) 2/1
(D) 3/2
(E) 1/1

5. A particle of mass m undergoes harmonic oscillation with period T_0. A force f proportional to the speed v of the particle, $f = -bv$, is introduced. If the particle continues to oscillate, the period with f acting is

(A) larger than T_0
(B) smaller than T_0
(C) independent of b
(D) dependent linearly on b
(E) constantly changing



6. A bead is constrained to slide on a frictionless rod that is fixed at an angle θ with a vertical axis and is rotating with angular frequency ω about the axis, as shown above. Taking the distance s along the rod as the variable, the Lagrangian for the bead is equal to

(A) $\frac{1}{2}m\dot{s}^2 - mgs\cos\theta$

(B) $\frac{1}{2}m\dot{s}^2 + \frac{1}{2}m(\omega s)^2 - mgs$

(C) $\frac{1}{2}m\dot{s}^2 + \frac{1}{2}m(\omega s\cos\theta)^2 + mgs\cos\theta$

(D) $\frac{1}{2}m(\dot{s}\sin\theta)^2 - mgs\cos\theta$

(E) $\frac{1}{2}m\dot{s}^2 + \frac{1}{2}\dot{m}(\omega s\sin\theta)^2 - mgs\cos\theta$

7. A lump of clay whose rest mass is 4 kilograms is traveling at three-fifths the speed of light when it collides head-on with an identical lump going the opposite direction at the same speed. If the two lumps stick together and no energy is radiated away, what is the mass of the composite lump?

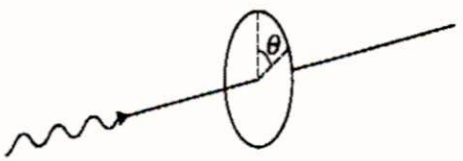
(A) 4 kg
(B) 6.4 kg
(C) 8 kg
(D) 10 kg
(E) 13.3 kg

8. An atom moving at speed $0.3c$ emits an electron along the same direction with speed $0.6c$ in the internal rest frame of the atom. The speed of the electron in the lab frame is equal to

(A) $0.25c$
(B) $0.51c$
(C) $0.66c$
(D) $0.76c$
(E) $0.90c$

9. A light source is at the bottom of a pool of water (the index of refraction of water is 1.33). At what minimum angle of incidence will a ray be totally reflected at the surface?

(A) 0°
(B) 25°
(C) 50°
(D) 75°
(E) 90°



10. A steady beam of light is normally incident on a piece of polaroid. As the polaroid is rotated around the beam axis, the transmitted intensity varies as $A + B\cos 2\theta$, where θ is the angle of rotation, and A and B are constants with $A > B > 0$. Which of the following may be correctly concluded about the incident light?

(A) The light is completely unpolarized.
(B) The light is completely plane polarized.
(C) The light is partly plane polarized and partly unpolarized.
(D) The light is partly circularly polarized and partly unpolarized.
(E) The light is completely circularly polarized.

11. Consider two horizontal glass plates with a thin film of air between them. For what values of the thickness of the film of air will the film, as seen by reflected light, appear bright if it is illuminated normally from above by blue light of wavelength 488 nanometers?

(A) 0, 122 nm, 244 nm
(B) 0, 122 nm, 366 nm
(C) 0, 244 nm, 488 nm
(D) 122 nm, 244 nm, 366 nm
(E) 122 nm, 366 nm, 610 nm

12. Light of wavelength 500 nanometers is incident on sodium, with work function 2.28 electron volts. What is the maximum kinetic energy of the ejected photoelectrons?

(A) 0.03 eV
(B) 0.2 eV
(C) 0.6 eV
(D) 1.3 eV
(E) 2.0 eV

13. A particle of mass m is acted on by a harmonic force with potential energy function $V(x) = m\omega^2 x^2/2$ (a one-dimensional simple harmonic oscillator). If there is a wall at $x = 0$ so that $V = \infty$ for $x < 0$, then the energy levels are equal to

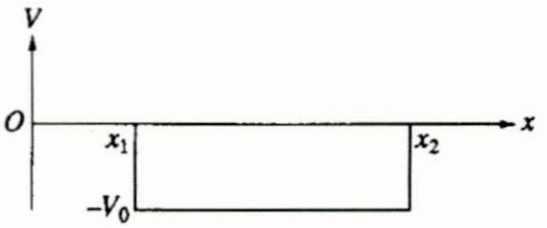
(A) $0, \hbar\omega, 2\hbar\omega, \ldots$

(B) $0, \frac{\hbar\omega}{2}, \hbar\omega, \ldots$

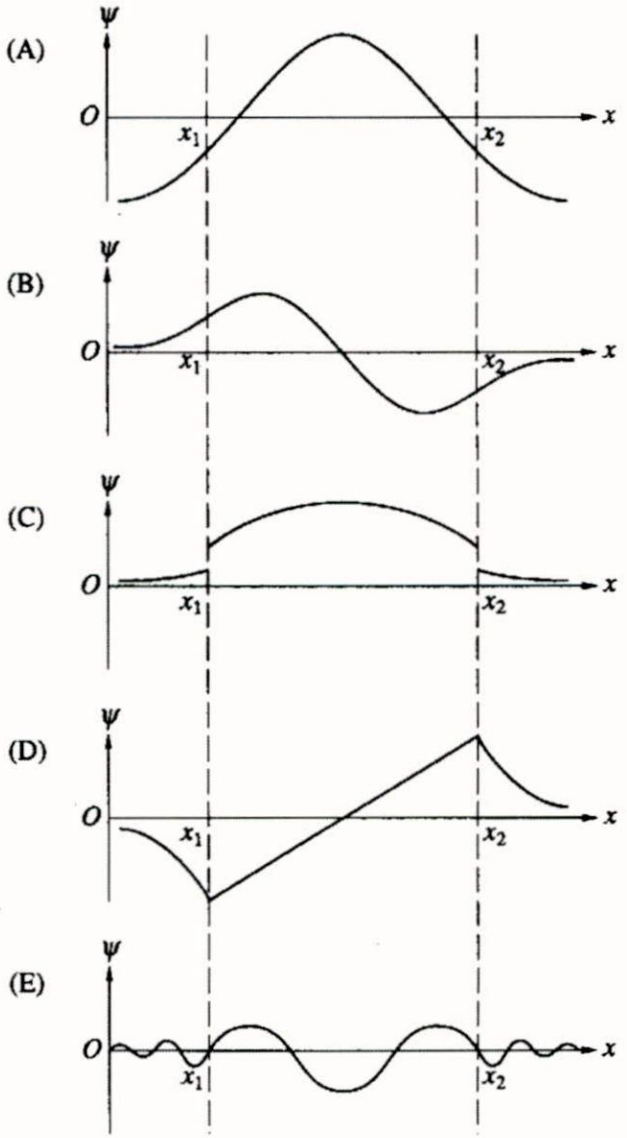
(C) $\frac{\hbar\omega}{2}, \frac{3\hbar\omega}{2}, \frac{5\hbar\omega}{2}, \ldots$

(D) $\frac{3\hbar\omega}{2}, \frac{7\hbar\omega}{2}, \frac{11\hbar\omega}{2}, \ldots$

(E) $0, \frac{3\hbar\omega}{2}, \frac{5\hbar\omega}{2}, \ldots$



14. An attractive, one-dimensional square well has depth V_0 as shown above. Which of the following best shows a possible wave function for a bound state?

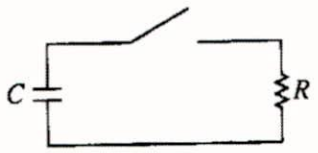


15. The ground-state energy of positronium is most nearly equal to

(A) −27.2 eV
(B) −13.6 eV
(C) −6.8 eV
(D) −3.4 eV
(E) 13.6 eV

16. In the spectrum of hydrogen, what is the ratio of the longest wavelength in the Lyman series ($n_f = 1$) to the longest wavelength in the Balmer series ($n_f = 2$) ?

(A) 5/27
(B) 1/3
(C) 4/9
(D) 3/2
(E) 3



17. The capacitor in the circuit shown above is initially charged. After closing the switch, how much time elapses until one-half of the capacitor's initial stored energy is dissipated?

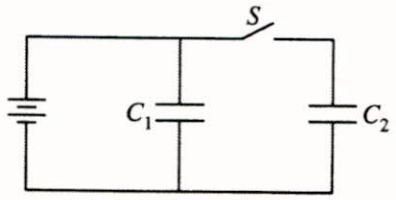
(A) RC

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

(C) $\frac{RC}{4}$

(D) $2RC \ln(2)$

(E) $\frac{RC \ln(2)}{2}$



18. Two real capacitors of equal capacitance ($C_1 = C_2$) are shown in the figure above. Initially, while the switch S is open, one of the capacitors is uncharged and the other carries charge Q_0. The energy stored in the charged capacitor is U_0. Sometime after the switch is closed, the capacitors C_1 and C_2 carry charges Q_1 and Q_2, respectively; the voltages across the capacitors are V_1 and V_2; and the energies stored in the capacitors are U_1 and U_2. Which of the following statements is INCORRECT?

(A) $Q_0 = \frac{1}{2}(Q_1 + Q_2)$

(B) $Q_1 = Q_2$

(C) $V_1 = V_2$

(D) $U_1 = U_2$

(E) $U_0 = U_1 + U_2$

19. The adiabatic expansion of an ideal gas is described by the equation $PV^\gamma = C$, where γ and C are constants. The work done by the gas in expanding adiabatically from the state $(V_i,\ P_i)$ to $(V_f,\ P_f)$ is equal to

(A) $P_f V_f$

(B) $\frac{(P_i + P_f)}{2}(V_f - V_i)$

(C) $\frac{P_f V_f - P_i V_i}{1 - \gamma}$

(D) $\frac{P_i (V_f^{1+\gamma} - V_i^{1+\gamma})}{1 + \gamma}$

(E) $\frac{P_f (V_f^{1-\gamma} - V_i^{1-\gamma})}{1 + \gamma}$

20. A body of mass m with specific heat C at temperature 500 K is brought into contact with an identical body at temperature 100 K, and the two are isolated from their surroundings. The change in entropy of the system is equal to

(A) $(4/3)mC$
(B) $mC\ln(9/5)$
(C) $mC\ln(3)$
(D) $-mC\ln(5/3)$
(E) 0

21. For an ideal diatomic gas in thermal equilibrium, the ratio of the molar heat capacity at constant volume at very high temperatures to that at very low temperatures is equal to

(A) 1
(B) 5/3
(C) 2
(D) 7/3
(E) 3

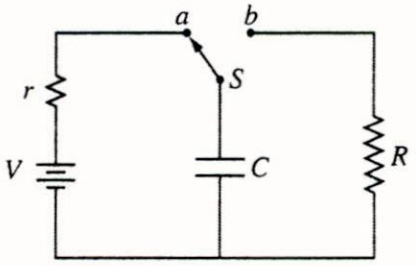


Figure 1

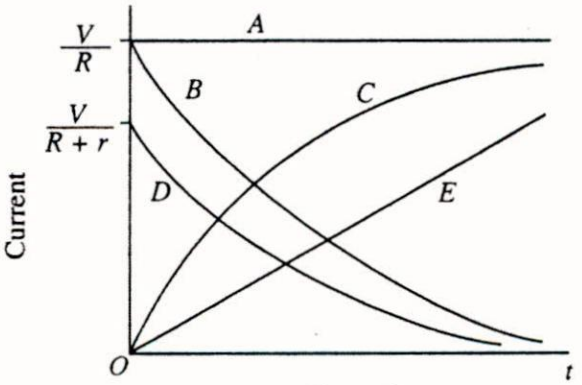
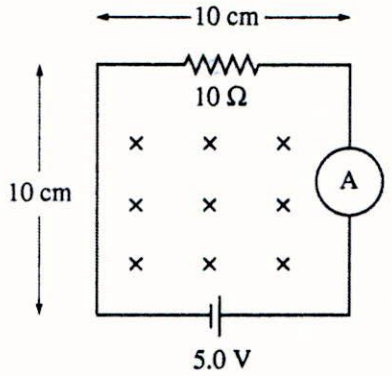


Figure 2

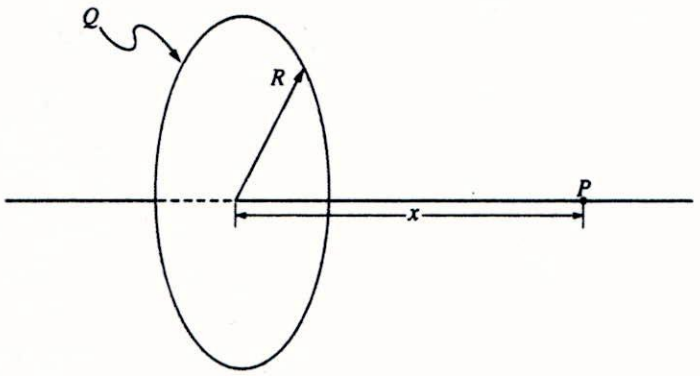
22. The capacitor shown in Figure 1 above is charged by connecting switch S to contact a. If switch S is thrown to contact b at time $t = 0$, which of the curves in Figure 2 above represents the magnitude of the current through the resistor R as a function of time?

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



23. The circuit shown above is in a uniform magnetic field that is into the page and is decreasing in magnitude at the rate of 150 tesla/second. The ammeter reads

(A) 0.15 A
(B) 0.35 A
(C) 0.50 A
(D) 0.65 A
(E) 0.80 A



24. The electric potential at a point P, which is located on the axis of symmetry a distance x from the center of the ring, is given by

(A) $\frac{Q}{4\pi\varepsilon_0 x}$

(B) $\frac{Q}{4\pi\varepsilon_0\sqrt{R^2 + x^2}}$

(C) $\frac{Qx}{4\pi\varepsilon_0(R^2 + x^2)}$

(D) $\frac{Qx}{4\pi\varepsilon_0(R^2 + x^2)^{3/2}}$

(E) $\frac{QR}{4\pi\varepsilon_0(R^2 + x^2)}$

25. In an n-type semiconductor, which of the following is true of impurity atoms?

(A) They accept electrons from the filled valence band into empty energy levels just above the valence band.
(B) They accept electrons from the filled valence band into empty energy levels just below the valence band.
(C) They accept electrons from the conduction band into empty energy levels just below the conduction band.
(D) They donate electrons to the filled valence band from donor levels just above the valence band.
(E) They donate electrons to the conduction band from filled donor levels just below the conduction band.

26. Which of the following reasons explains why a photon cannot decay to an electron and a positron ($\gamma \rightarrow e^+ + e^-$) in free space?

(A) Linear momentum and energy are not both conserved.
(B) Linear momentum and angular momentum are not both conserved.
(C) Angular momentum and parity are not both conserved.
(D) Parity and strangeness are not both conserved.
(E) Charge and lepton number are not both conserved.

27. In laboratory experiments, graphs are employed to determine how one measured variable depends on another. These graphs generally fall into three categories: linear, semilog (logarithmic *versus* linear), and log-log. Which type of graph listed in the third column below would NOT be the best for plotting data to test the relationship given in the first and second columns?

Relation	Variables Plotted	Type of Graph
(A) $dN/dt \propto e^{-2t}$	Activity *vs.* time for a radioactive isotope	Semilog
(B) $eV_s = hf - W$	Stopping potential *vs.* frequency for the photoelectric effect	Linear
(C) $s \propto t^2$	Distance *vs.* time for an object undergoing constant acceleration	Log-log
(D) $V_{out}/V_{in} \propto 1/\omega$	Gain *vs.* frequency for a low-pass filter	Linear
(E) $P \propto T^4$	Power radiated *vs.* temperature for blackbody radiation	Log-log

If you finish before time is called, you may check your work on this test.

TABLE OF INFORMATION

Rest mass of the electron	$m_e = 9.11 \times 10^{-31}$ kg
Magnitude of the electron charge	$e = 1.60 \times 10^{-19}$ C
Avogadro's number	$N_A = 6.02 \times 10^{23}$
Universal gas constant	$R = 8.31$ J/(mol • K)
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ J/K
Speed of light	$c = 3.00 \times 10^{8}$ m/s
Planck's constant	$h = 6.63 \times 10^{-34}$ J • s $= 4.14 \times 10^{-15}$ eV • s
	$\hbar = h/2\pi$
	$hc = 1240$ eV • nm
Vacuum permittivity	$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/(N • m^2)
Vacuum permeability	$\mu_0 = 4\pi \times 10^{-7}$ T • m/A
Universal gravitational constant	$G = 6.67 \times 10^{-11}$ m^3/(kg • s^2)
Acceleration due to gravity	$g = 9.80$ m/s^2
1 atmosphere pressure	1 atm $= 1.0 \times 10^5$ N/m^2 $= 1.0 \times 10^5$ Pa
1 angstrom	1Å $= 1 \times 10^{-10}$ m $= 0.1$ nm

Prefixes for Powers of 10

10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Rotational inertia about center of mass

Rod	$\frac{1}{12} M\ell^2$
Disc	$\frac{1}{2} MR^2$
Sphere	$\frac{2}{5} MR^2$