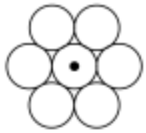
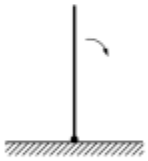
GRE Physics Practice Test 3



25. Seven pennies are arranged in a hexagonal, planar pattern so as to touch each neighbor, as shown in the figure above. Each penny is a uniform disk of mass m and radius r. What is the moment of inertia of the system of seven pennies about an axis that passes through the center of the central penny and is normal to the plane of the pennies?

(A) $(7/2)\ mr^2$
(B) $(13/2)\ mr^2$
(C) $(29/2)\ mr^2$
(D) $(49/2)\ mr^2$
(E) $(55/2)\ mr^2$



26. A thin uniform rod of mass M and length L is positioned vertically above an anchored frictionless pivot point, as shown above, and then allowed to fall to the ground. With what speed does the free end of the rod strike the ground?

(A) $\sqrt{\frac{1}{3}gL}$
(B) $\sqrt{gL}$
(C) $\sqrt{3gL}$
(D) $\sqrt{12gL}$
(E) $12\sqrt{gL}$

27. The eigenvalues of a Hermitian operator are always

(A) real
(B) imaginary
(C) degenerate
(D) linear
(E) positive

$$|\psi_1\rangle = 5|1\rangle - 3|2\rangle + 2|3\rangle$$
$$|\psi_2\rangle = |1\rangle - 5|2\rangle + x|3\rangle$$

28. The states $|1\rangle$, $|2\rangle$, and $|3\rangle$ are orthonormal. For what value of x are the states $|\psi_1\rangle$ and $|\psi_2\rangle$ given above orthogonal?

(A) 10
(B) 5
(C) 0
(D) −5
(E) −10

29. The state $\psi = \frac{1}{\sqrt{6}}\psi_{-1} + \frac{1}{\sqrt{2}}\psi_1 + \frac{1}{\sqrt{3}}\psi_2$ is a linear combination of three orthonormal eigenstates of the operator $\hat{O}$ corresponding to eigenvalues −1, 1, and 2. What is the expectation value of $\hat{O}$ for this state?

(A) $\frac{2}{3}$
(B) $\sqrt{\frac{7}{6}}$
(C) 1
(D) $\frac{4}{3}$
(E) $\frac{(\sqrt{3} + 2\sqrt{2} - 1)}{\sqrt{6}}$

30. Which of the following functions could represent the radial wave function for an electron in an atom? (r is the distance of the electron from the nucleus; A and b are constants.)

I. $A\,e^{-br}$
II. $A\sin(br)$
III. A/r

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

31. Positronium is an atom formed by an electron and a positron (antielectron). It is similar to the hydrogen atom, with the positron replacing the proton. If a positronium atom makes a transition from the state with $n = 3$ to a state with $n = 1$, the energy of the photon emitted in this transition is closest to

(A) 6.0 eV
(B) 6.8 eV
(C) 12.2 eV
(D) 13.6 eV
(E) 24.2 eV

32. If the total energy of a particle of mass m is equal to twice its rest energy, then the magnitude of the particle's relativistic momentum is

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

33. If a charged pion that decays in 10^{-8} second in its own rest frame is to travel 30 meters in the laboratory before decaying, the pion's speed must be most nearly

(A) 0.43×10^8 m/s
(B) 2.84×10^8 m/s
(C) 2.90×10^8 m/s
(D) 2.98×10^8 m/s
(E) 3.00×10^8 m/s

34. In an inertial reference frame S, two events occur on the x-axis separated in time by Δt and in space by Δx. In another inertial reference frame S', moving in the x-direction relative to S, the two events could occur at the same time under which, if any, of the following conditions?

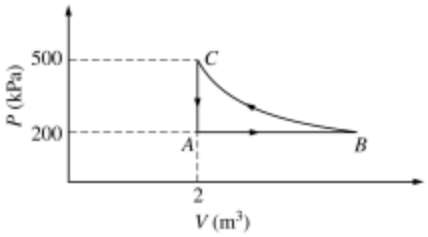
(A) For any values of Δx and Δt
(B) Only if $|\Delta x/\Delta t| < c$
(C) Only if $|\Delta x/\Delta t| > c$
(D) Only if $|\Delta x/\Delta t| = c$
(E) Under no condition

35. If the absolute temperature of a blackbody is increased by a factor of 3, the energy radiated per second per unit area does which of the following?

(A) Decreases by a factor of 81.
(B) Decreases by a factor of 9.
(C) Increases by a factor of 9.
(D) Increases by a factor of 27.
(E) Increases by a factor of 81.

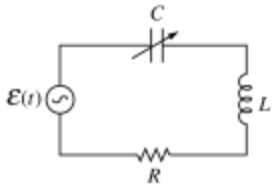
36. Consider the quasi-static adiabatic expansion of an ideal gas from an initial state i to a final state f. Which of the following statements is NOT true?

(A) No heat flows into or out of the gas.
(B) The entropy of state i equals the entropy of state f.
(C) The change of internal energy of the gas is $-\int PdV$.
(D) The mechanical work done by the gas is $\int PdV$.
(E) The temperature of the gas remains constant.



37. A constant amount of an ideal gas undergoes the cyclic process $ABCA$ in the PV diagram shown above. The path BC is isothermal. The work done by the gas during one complete cycle, beginning and ending at A, is most nearly

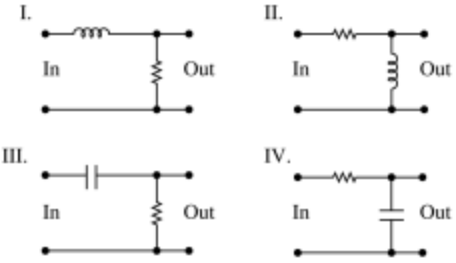
(A) 600 kJ
(B) 300 kJ
(C) 0
(D) −300 kJ
(E) −600 kJ



38. An AC circuit consists of the elements shown above, with $R = 10{,}000$ ohms, $L = 25$ millihenries, and C an adjustable capacitance. The AC voltage generator supplies a signal with an amplitude of 40 volts and angular frequency of 1,000 radians per second. For what value of C is the amplitude of the current maximized?

(A) 4 nF
(B) 40 nF
(C) 4 μF
(D) 40 μF
(E) 400 μF

39. Which two of the following circuits are high-pass filters?



(A) I and II
(B) I and III
(C) I and IV
(D) II and III
(E) II and IV