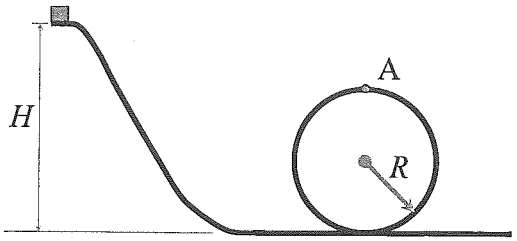
考題皆為單選題，請在答案卡上作答

共25題，每題4分，答錯不倒扣。

1. Consider a block sliding on a frictionless loop-the-loop track of radius R shown in the figure. Find the minimum height H at which the block starts from rest and still contacts the track when it passes the highest point of the track (point A).

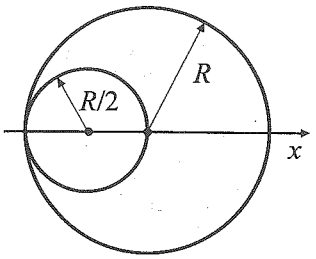


(A) 0.5 R (B) R (C) 1.5 R (D) 2 R (E) 2.5 R

2. M_E and R_E are the mass and radius of the Earth, respectively. Neglecting the Earth's rotation, what is the energy needed to launch an object of mass m from the Earth surface into a circular orbital at altitude R_E?

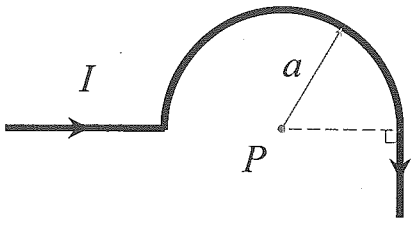
(A) 0 (B) $\frac{GM_Em}{4R_E}$ (C) $\frac{GM_Em}{2R_E}$ (D) $\frac{3GM_Em}{4R_E}$ (E) $\frac{GM_Em}{R_E}$

3. A uniform sphere of radius R has a spherical hole of radius $R/2$ removed. The center of the sphere and the hole are located at $x = 0$ and $x = -R/2$, as shown in the figure. Where is the center of the mass of this system?



(A) $x = 0$ (B) $x = \frac{1}{4}R$ (C) $x = \frac{1}{6}R$ (D) $x = \frac{1}{10}R$ (E) $x = \frac{1}{14}R$

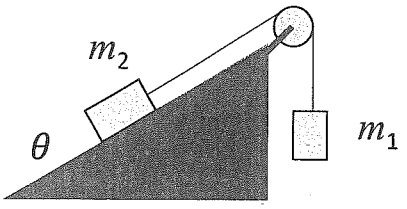
4. Consider an infinite wire carrying a current I as shown in the figure. The curve is a semicircle of radius a. What is the magnetic field at the center of the semicircle P? μ_0 is the vacuum permeability.



(A) $\frac{\mu_0 I}{4\pi a}(\pi + 1)$ (B) $\frac{\mu_0 I}{4\pi a}(\pi + 2)$ (C) $\frac{\mu_0 I}{4\pi a}(2\pi + 1)$ (D) $\frac{\mu_0 I}{4\pi a}(2\pi + 2)$

(E) none of the above

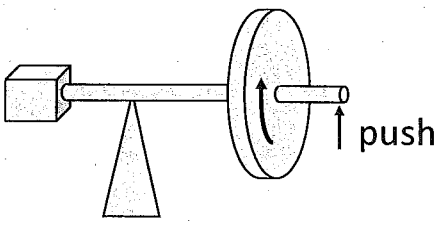
5. Two blocks m_1(5 kg) and m_2(1 kg) are connected with a string via a pulley. The block m_2 are on a frictionless incline of $\theta = 30°$, as shown in the figure. What is the tension of the string? The acceleration of gravity is 10 m/s^2.



(A) 4.2 N (B) 8.3 N (C) 12.5 N (D) 15.6 N (E) 18.8 N

6. A thin uniform rod of length L is pivoted about a horizontal axis at one end. What is the angular frequency when it does small-angle oscillations? Assume that the acceleration of gravity is g.
(A) $\sqrt{g/L}$ (B) $\sqrt{g/2L}$ (C) $\sqrt{3g/2L}$ (D) $\sqrt{2g/L}$ (E) none of the above.

7. The figure shows a gyroscope, consisting of a solid disk and a weight mounted on a shaft. The disk spins about the shaft freely. The shaft is mounted on stand and can pivot freely. The position of the weight is adjusted, so the weight balances the disk. The spinning direction of the disk is as indicted. If you gently push the end of the shaft upward as shown in the figure, the end of the shaft will move
(A) toward you (B) away from you (C) downward (D) upward (E) the disk does not move.



8. A 2-m-long string is clamped at both ends. If the wave speed on the string is 60 m/s, what is the lowest standing-wave frequency?
(A) 7.5 Hz (B) 10 Hz (C) 15 Hz (D) 20 Hz (E) 30 Hz

9. The pressure of an ideal gas becomes three times of its initial pressure during an adiabatic process. What is the ratio of its final volume to its initial volume? γ is the ratio of the constant-pressure specific heat to the constant-volume specific heat of this.
(A) $1/3$ (B) $3^{-\gamma}$ (C) 3^{γ} (D) $3^{-1/\gamma}$ (E) $3^{1/\gamma}$

10. An ideal gas is slowly compressed to one-half its original volume with no change in pressure. If the original root-mean-square speed of the gas molecules was v, the new speed after the compression is
(A) v (B) $2v$ (C) $\sqrt{2}v$ (D) $v/2$ (E) $v/\sqrt{2}$

11. When n moles of a monatomic ideal gas doubles its volume at constant temperature, how much does its entropy change? R is the universal gas constant.
(A) $nR\ln 2$ (B) nR (C) $\frac{3}{2}nR$ (D) $2nR$ (E) $\frac{5}{2}nR$

12. A Carnot engine operates between reservoirs at 500 K and 300 K. When it discharges 150 J to the lower-temperature reservoir, how much is the work done?
(A) 50 J (B) 100 J (C) 150 J (D) 200 J (E) 250 J

13. When an ideal gas undergo an adiabatic free expansion, what remains unchanged during the process?
(A) volume (B) temperature (C) pressure (D) entropy (E) density

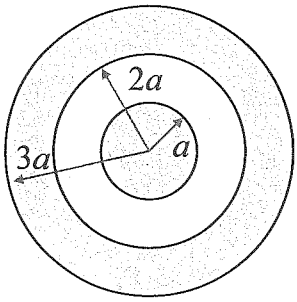
14. Consider a large open tank with a small hole at its bottom. The tank is filled with water to a height of 1.25 m. What is the speed at which the water exits the tank through the hole? The acceleration of gravity is 10 m/s^2

(A) 1.25 m/s (B) 3.53 m/s (C) 5 m/s (D) 12.5 m/s (E) 25 m/s

15. An electric dipole with a dipole moment p is within a uniform electric field E. If the electric dipole is at an angle of 60° to the electric field, what is the external work needed to rotate the electric dipole to be perpendicular to the electric field?

(A) $\frac{1}{2}pE$ (B) $-\frac{1}{2}pE$ (C) $\frac{\sqrt{3}}{2}pE$ (D) $-\frac{\sqrt{3}}{2}pE$ (E) $\left(1-\frac{\sqrt{3}}{2}\right)pE$

16. Consider a system consisting of a conducting sphere and a conducting spherical shell that are concentric. The radius of the sphere is a; the radii of the inner and outer surfaces of the shell are $2a$ and $3a$, respectively, as shown in the figure. If the sphere carries a net charge of $-Q$ and the shell carries a net charge of $+2Q$, what is the electric potential at a distance of $a/2$ from the center when the system is in electrostatic equilibrium? Assume that the zero of potential is at infinity. k is the Coulomb's constant.

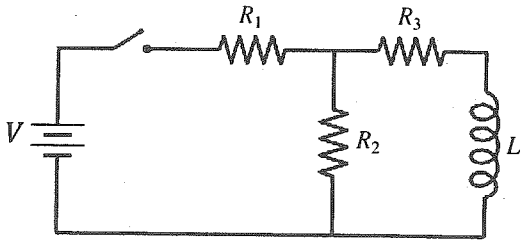


(A) $-kQ/a$ (B) $-2kQ/a$ (C) $2kQ/a$ (D) $kQ/3a$ (E) $-kQ/6a$

17. The main reason for the generation of paramagnetism in materials are:

(A) There is an effect of exchange coupling between electrons.
(B) The magnetic dipoles of electrons tend to align with the applied magnetic field.
(C) There are forces between the magnetic dipoles of electrons.
(D) There are torques between the magnetic dipoles of electrons.
(E) None of the above.

18. Consider the circuit in the figure, in which $V = 30$ V, $R_1 = 10\ \Omega$, $R_2 = 15\ \Omega$, $R_3 = 30\ \Omega$, and $L = 20$ mH. The switch is initially open. If the switch is closed for a long time and reopened, what is the voltage across R_2 when the switch is reopened?



(A) 7.5 V (B) 15 V (C) 22.5 V (D) 30 V (E) 45 V

19. Monochromatic light is normally incident on a diffraction grating that has 10000 slits and is 1 cm wide. If the second-order line is deviated at 30 degrees, what is the wavelength of the incident light?

(A) 250 nm (B) 433 nm (C) 500 nm (D) 866 nm (E) 1000 nm

20. Consider a purely resistive heater connected to an AC power source (rms voltage 120 V, frequency 60 Hz) with an average heating power of 1 kW. If an inductor is connected in series with the heater, causing the average heating power to drop to 1/4 of its original value, what is the phase angle between the voltage and the current?
(A) 15° (B) 30° (C) 45° (D) 60° (E) 90°

21. Consider an ideal parallel plate capacitor that is charged. If the capacitor plates are slightly pulled apart, which of the following statements is correct during the process?
(A) The electric field strength inside the capacitor decreases.
(B) The energy density inside the capacitor increases.
(C) The potential difference between the capacitor plates remains unchanged.
(D) The energy stored in the capacitor increases.
(E) The capacitance of the capacitor increases.

22. For a hydrogen atom, the number of states in a shell with principal quantum number n is
(A) n (B) $2n$ (C) $2n+1$ (D) n^2 (E) $2n^2$

23. If the average intensity (energy per unit time per unit area) of an electromagnetic wave at some point in space is $\bar{S}$, what is the peak electric field at that point? ϵ_0 and μ_0 are the vacuum permittivity and permeability, respectively.
(A) $\sqrt{2\epsilon_0 c\bar{S}}$ (B) $\sqrt{2\mu_0 c\bar{S}}$ (C) $\sqrt{2\epsilon_0\bar{S}/c}$ (D) $\sqrt{2\mu_0\bar{S}/c}$ (E) $\sqrt{2\bar{S}/\mu_0 c}$

24. Consider a soap film of thickness t and index of refraction n (>1) suspending in air (index of refraction ~1). Light of wavelength λ is incident on the soap normally. If the intensity of the reflection is 0 (destructive completely), what is the maximum of λ?
(A) nt (B) $2t$ (C) $2nt$ (D) $4t$ (E) $4nt$

25. In an experiment of photoelectric effect, when the light intensity increases,
(A) the photoelectric current decreases
(B) the stopping potential decreases
(C) the photoelectric current does not change
(D) the stopping potential does not change
(E) None of the above