考題為選擇題，請在答案卡上作答。題目分為單選與複選兩部分，共25題，每題4分，不倒扣。複選題必須所有選項都選對才得該題分數。數值計算請選擇最接近正確值的答案。

Important contants:

permittivity of vacuum: $\epsilon_0 = 8.85 \times 10^{-12} \mathrm{C}^2/N \cdot \mathrm{m}^2$.
Radius of the Earth: $R_E = 6371$ km.
Permeability of vacuum $\mu_0 = 4\pi \times 10^{-7}$ T · m/A.
Astronomical Unit, AU $= 1.496 \times 10^8$ km.
Gravitational Const. $G = 6.674 \times 10^{-11}$ in SI unit.
Mass of the Earth $M_E = 5.972 \times 10^{24}$ kg.
Charge of an electron $= 1.6 \times 10^{-19}$ Coulomb.
Mass of the Sun, $M_\odot = 1.989 \times 10^{30}$ kg.

單選題

1. If we denote the dimension of length as $[L]$, dimension of time as $[T]$, and dimension of mass as $[M]$, what is the dimension of the universal gravitational constant G? (A) $[L]^2[T]^{-2}[M]$, (B) $[L]^2[T]^{-3}[M]^{-1}$, (C) $[L]^{-2}[T]^2[M]^{-1}$, (D) $[L]^3[T]^{-2}[M]^{-1}$, (E) $[L]^3[T]^2[M]^{-2}$.

2. A small ball of mass m is suspended in an elevator by a string of length L. The string does not stretch and its mass can be ignored. If the elevator located at the surface of the Earth and moves upward with an acceleration a, what is the frequency of the ball's oscillatory motion? (A) $m(g-a)/(2\pi L)$, (B) $m(g+a)/(2\pi L)$, (C) $\frac{1}{2\pi}\sqrt{g/L}$, (D) $\frac{1}{2\pi}\sqrt{(g-a)/L}$, (E) $\frac{1}{2\pi}\sqrt{(g+a)/L}$. Here g is the gravitational acceleration on Earth's surface.

3. A block of mass 5 kg moving on a frictionless surface with a speed of 3 m/s collides with another block of mass 7 kg at rest. After the collision the two blocks stick together. What is the speed of the combined object? (A) 1.25 m/s, (B) 1.5 m/s, (C) 1 m/s, (D) 0.5 m/s, (E) 2.0 m/s.

4. A satellite is on a circular orbit 3600km above ground. How much speed increase is needed for it to escape from Earth's gravity? (A) 11.2 km/s; (B) 3.3 km/s; (C) 6.4 km/s; (D) 2.6 km/s; (E) 1.0 km/s.

5. A space craft is launched from the surface of the Earth with a heliocentric speed of 42 km/s (the speed relative to the Sun). What is its speed when it reaches a distance of 5 AU from the Sun? Note: you have to include the gravitational potential of the Earth as well as the Sun in the calculation. (A) 12 km/s; (B) 15km/s; (C) 18 km/s; (D) 21 km/s; (E) 24km/s.

注意:背面有試題

6. A solid spherical marble starts from rest and rolls without slipping on the loop-the-loop track in figure 1. What is the minimum starting height h from which the marble will remain on the track through the loop. Assume the marbles radius is small compared with R.
(A) $2.5R$; (B) $2.7R$; (C) $2.9R$; (D) $3.1R$; (E) $3.3R$. (Note: the moment of inertial for a solid spherical object is $\frac{2}{5}mr^2$, where m is the mass of the object and r is its radius.)

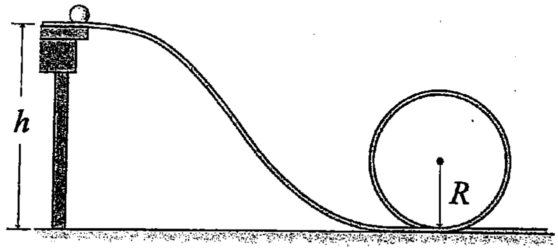


Figure 1: Figure for problem 6.

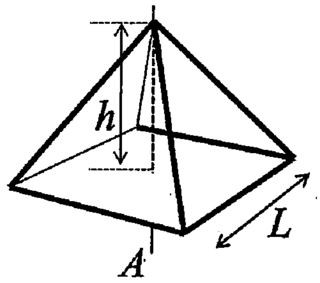


Figure 2: Figure for problem 7.

7. What is the moment of inertia related to central axis A of a uniform solid pyramid of mass M and height h, with a square bottom of side L, as shown in figure 2. (A) $0.4ML^3/h$; (B) $0.2MLh$; (C) $0.1ML^2$; (D) $0.1MLh$; (E) $0.2ML^2$.

8. A thin circular disk of radius R carries a total charge Q uniformly distributed on its surface. Assuming symmetric electric field on the two sides of the disk, which of the following expressions is a good approximation of the electric field strength at a distance r above the center of the disk, where $r \ll R$? (A) Q/ϵ_0; (B) $Q/(4\pi\epsilon_0 r)$; (C) $Q/(4\pi\epsilon_0 r^2)$; (D) $Q/(2\pi\epsilon_0 R^2)$; (E) $Q/(4\pi\epsilon_0 R^2)$.

9. Same setting as in problem 8, but with $r \gg R$. Which of the following is a good approximation of the electric field strength? (A) Q/ϵ_0; (B) $Q/(4\pi\epsilon_0 r)$; (C) $Q/(4\pi\epsilon_0 r^2)$; (D) $Q/(2\pi\epsilon_0 R^2)$; (E) $Q/(4\pi\epsilon_0 R^2)$.

10. A piston system containing 1 mole of ideal gas in a 10 liter volume initially. The system is put in thermal contact with the environment at 20°C and 1 atm of pressure. The piston is then released and the volume expands slowly in a quasi-static manner. The temperature is maintained at 20°C during the whole process. The expansion stops when the pressure inside the piston reaches 1 atm. What is the volume of the gas chamber after the expansion? (The universal ideal gas constant, R, is 0.082 Liter-atm/K/mole.) (A) 24.1 liter; (B) 22.1 liter; (C) 18.4 liter; (D) 16.9 liter; (E) 12.3 liter.

11. Same setting as problem 10, what is the work done by the piston during the expansion process? (A) 24 J; (B) 21 J; (C) 18 J; (D) 16 J; (E) 0 J.

12. Same initial condition as in problem 10, but this time we insulate the system from the environment such that the expansion process is quasi-static and adiabatic. Starting with 20°C and 10 liter, what is the volume of the chamber when the pressure reaches 1 atm? Assuming the specific heat are $C_v = \frac{3}{2}R$ and $C_p = \frac{5}{2}R$. (A) 24 liter; (B) 22.1 liter; (C) 18.4 liter; (D) 16.9 liter; (E) 12.3 liter.

13. Same as problem 12, what is the change of entropy during this process? (A) 24 J/K; (B) 21 J/K; (C) 18 J/K; (D) 16 J/K; (E) 0 J/K.

14. In electrostatic equilibrium, the electric field just outside any charged conductor is (A) always zero; (B) always perpendicular to the surface of the conductor; (C) always parallel to the surface of the conductor, along the gradient of the surface charge distribution; (D) always parallel to the surface, but perpendicular to the gradient of the surface charge distribution, (E) of no particular direction.

15. A string of length L and linear density λ is stretched to a tension T. What is the expression of its resonance frequencies of standing waves? (A) $2\pi n^2\sqrt{\frac{T}{\lambda L}}$; (B) $2\pi\frac{n}{L}\sqrt{\frac{T}{\lambda}}$; (C) $2\pi nT\sqrt{\frac{1}{\lambda L}}$; (D) $\frac{n}{2L}\sqrt{\frac{T}{\lambda}}$; (E) $\frac{n^2}{2L}\frac{T}{\lambda}$, where n is any positive integer. (Hint: Wave equation of small displacement y is $T\frac{\partial^2 y}{\partial x^2} = \lambda\frac{\partial^2 y}{\partial t^2}$).

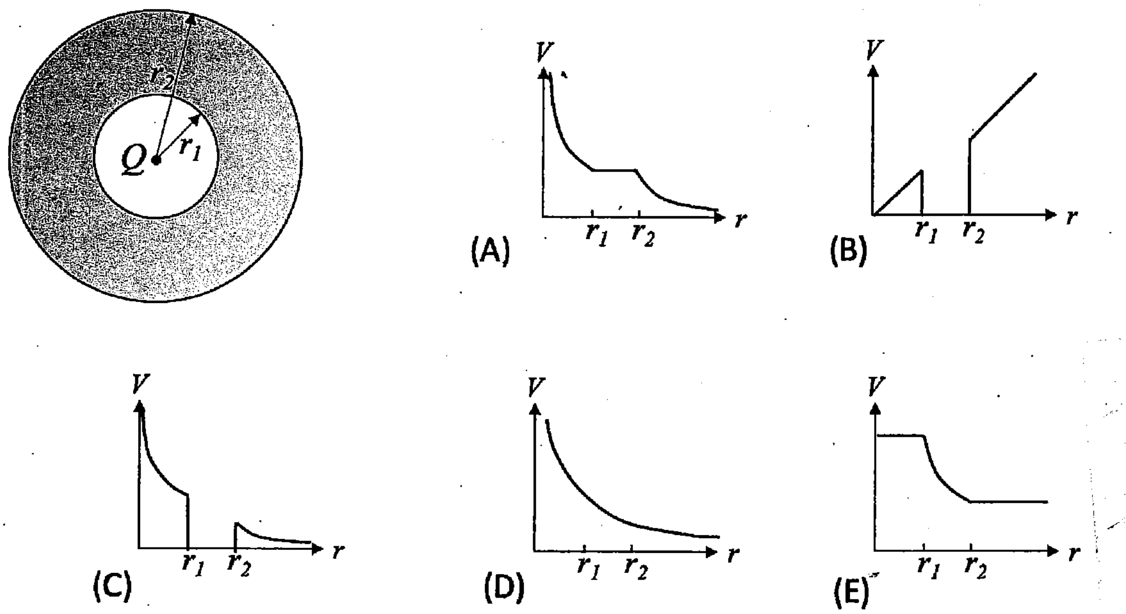
16. Two parallel infinite wires 2cm apart carry currents of 1A and 8A, separately. What is the force per meter between them? (A) 4×10^{-5} N/m; (B) 4×10^{-7} N/m; (C) $4\pi \times 10^{-7}$ N/m; (D) $8\pi \times 10^{-5}$ N/m; (E) 8×10^{-5} N/m;

17. A 1.2 mF capacitor is connected across a generator whose output is $V = V_0 \sin(2\pi ft)$, with $V_0 = 20$ V, $f = 60$ Hz, and t in seconds. Find the peak current and absolute value of the current at $t = 5$ms. (A) 9.05A, 2.80A; (B) 9.05A, 1.80A; (C) 1.44A, 0.45A; (D) 1.44A, 0.25A; (E) 9.05A, 8.61A.

18. The deBroglie wavelength of a non-relativistic particle with mass m and speed v is: (A) $\frac{2h}{mv^2}$; (B) $\frac{h}{mv}$; (C) $\frac{2hc}{mv^2}$; (D) $\frac{h}{mc}$; (E) $\frac{h}{mc^2}$. Here h is the Planck constant and c is the speed of light.

19. A solenoid of 10cm in diameter and 2.0m in length carries 25 Amperes current. It produces an internal magnetic field of 100 mT. How many turns of wire does this solenoid have? (A) 3183; (B) 32; (C) 6366; (D) 64; (E) 12732.

20. The following figure shows a conductive sphere with a spherical cavity in the center. The total charge on the conductor is zero, but a point charge Q is placed at the center of the cavity. How does the electric potential (V) as a function of the distance from the center (r) looks like?

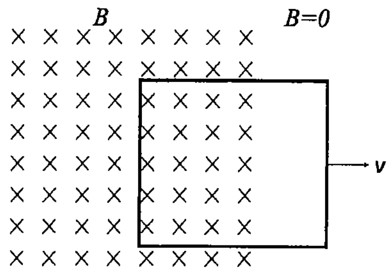


複選題

21. Two balls of masses $m_1 = 1$ kg and $m_2 = 100$ kg, with initial speed 1 m/s and 10 m/s, respectively, collide inelastically in space. They stick together after the collision. Which of the following is true in the Center of Mass Frame? (A) The total momentum does not change; (B) The total kinetic energy does not change; (C) The magnitude of velocity change of m_2 is less than that of m_1; (D) The magnitude of momentum change of m_2 is less than that of m_1; (E) The magnitude of kinetic energy change of m_2 is less than that of m_1.

22. Consider a damped harmonic oscillator, which of the following is true? (A) If it is underdamped, the resonant frequency increases with larger damping; (B) If it is underdamped, the amplitude decays faster with larger damping; (C) If it is underdamped, and is driven by an external sinusoidal force, the amplitude of the oscillation is maximum if the frequency of the force is the same as the resonance frequency; (D) In order to damp the kinetic energy and the elastic energy as fast as possible, one should design the oscillator to be at critical damping condition; (E) If it is overdamped, the system does not oscillate and returns to the equilibrium position slowly.

23. A square conductive loop of side L and resistance R is pulled with constant speed v out of a uniform magnetic field B. The magnetic field is perpendicular to and pointing into the plane of the loop, as shown in the figure. Which of the following is correct? (A) The induced EMF is BLv; (B) The induced current is BLv/R; (C) The force required to pull the loop is B^2L^2v/R; (D) The power required to pull the loop is $B^2L^2v^2/R^2$; (E) The direction of the electric current is clockwise.



24. A magnetic dipole made of a conductive ring carrying a current I. Observing from far away, which of the following statements are FALSE? (A) If the magnetic dipole is placed in a uniform magnetic field, it experiences no net magnetic force. (B) The magnetic dipole experiences a net torque if its dipole moment is parallel to the uniform magnetic field. (C) The magnetic dipole may experience a net force induced by another magnetic dipole. (D) The magnetic field induced by the magnetic dipole is approximately proportional to the area of the ring. (E) The magnetic field induced by the dipole is approximately inversely proportional to the square of the distance from it.

25. Which of the following is a statement or a consequence of 2nd law of thermal dynamics? (A) The efficiency of any heat engine operates between two heat reservoir is less or equal to the Carnot engine. (B) Heat can never pass from a colder to a warmer body without some other changes occurring at the same time. (C) Entropy of an object always increases when it is in contact with a heat reservoir. (D) Isolated perpetual motion machine is not possible. (E) The entropy of a thermal system going through a cyclic process always increases or stays the same after a full cycle.