(一)每一空格 5 分，僅需將答案寫出，不須寫步驟。

1. Assuming all in SI units, find the work done by the force $\mathbf{F}(x,y) = xy\,\mathbf{i} + 2y^2\,\mathbf{j}$ along the line $y = 2x$ form point (0,0) to (1,2), where **i** and **j** are the unit vectors in the x and y directions, respectively. [1] Is this force a conservative force? [2]
2. A 10 kg disk with radius 0.10 m is rolling down on a 30^0 ramp without sliding. If it starts at rest, what is the frictional force between the disk and the ramp? [3] The gravitational acceleration is about 10 m/s^2 in free fall. After 1 second of acceleration, what will be the angular momentum of this disk measured in the ramp frame? [4]
3. A tall cylindrical tank with radius 1.0 m is filled with water to 10 m high and is under the atmospheric pressure, P_0. There is a small hole with radius 0.010 m on the sidewall of the tank and water is coming out from that small hole. At some time, the hole is 5.0 m below the water surface. Estimate the pressure at the hole. [5] You can assume g is 10 m/s^2. What is the rate of change of the height of the water surface in SI unit, i.e. m/s, at that instant? [6]
4. One mole of an ideal monatomic gas, at an initial pressure of 8.31 kPa and an initial volume of 1.0 m^3, expands freely to its final volume 2.0 m^3. What is the entropy change? [7] If it expands under constant pressure 8.31 kPa to 2.0 m^3, what is the entropy change? [8] You can take the universal gas constant as R = 8.31 J/mol.K.
5. A rod of length l has a uniform linear charge density λ and a total charge Q. What is the magnitude of the electric field at a point P along the axis of the rod, a distance a away from one end of the rod (point P is located outside the rod). [9]
6. An insulating solid sphere of radius a has a uniform charge density ρ and carries a total positive charge Q. What is the magnitude of the electric field at a point P located at r ($r < a$) from the center of the sphere. [10]
7. A proton (m_p = 1.67 x 10^{-27} kg) is moving in a circular orbit of radius 15.0 cm in a uniform magnetic field of magnitude 0.50 tesla directed perpendicular to the velocity of the proton. The period of the circular motion of the proton is [11].
8. A beam of light of wavelength 550 nm traveling in air is incident on a slab of transparent material. The incident beam makes an angle of 45.0° with the normal, and the refracted beam makes an angle of 30.0° with the normal. The speed of the light in the material is [12]. The wavelength of the light in the material is [13].
9. What is the de Broglie wavelength for an electron (m_e = 9.11 x 10^{-31} kg) moving with a speed of 1.00 x 10^7 m/s. [14]
10. A long coaxial cable consists of two concentric cylindrical conductors of radii a and b and length l ($a < b << l$). The inner conductor is assumed to be a thin cylindrical shell. The conductors carry current I in opposite directions. Calculate the self inductance L of the cable [15] and the total energy stored in the magnetic field of the cable. [16]

(二)每題 10 分，請寫出步驟。

(1)Two waves, $A\sin(kx-\omega t)$ and $A\sin(kx+\omega t)$, are traveling along a string on the x axis with a linear density, μ. Find the energy density as a function of x, t, A, k, ω, and μ. Note that the energy includes both kinetic energy and potential energy. Show that the total energy between two nodal points is a constant, i.e. not a function of time, t.

(2)An electron is confined to a 1-dimensional box of length 0.100 nm. Please draw an energy level diagram for the electron for levels up to n = 4.