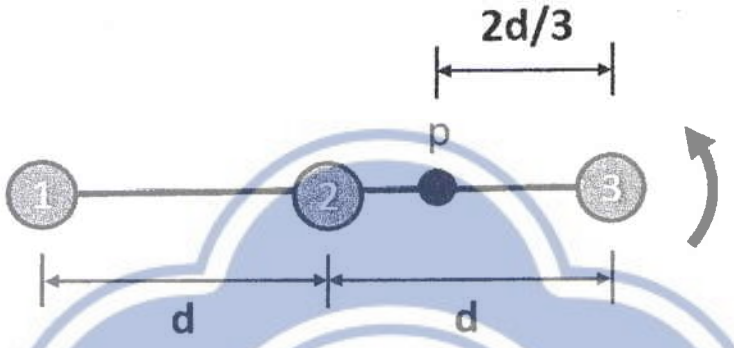
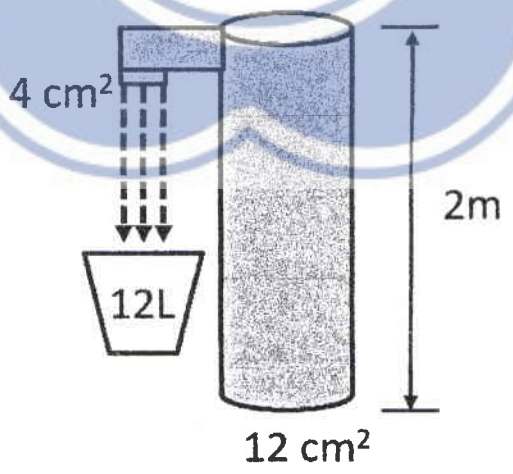
考試科目	普通物理	系所別	應用物理研究所	考試時間	2 月 3 日(六) 第一節

1. **(16%)** A rigid, massless rod (桿) has three particles with equal masses attached to it. The rod is free to rotate in a vertical plane about a frictionless (無摩擦) axle (軸) perpendicular to the rod through the point P and is released from rest in the horizontal position at t= 0. The mass of the particles is **m** and the distance between particles is **d.** Assume m and d are known, find (a) the moment of inertia of the system of three particles about the pivot, (b) the torque acting on the system at t = 0, (c) the angular acceleration of the system at t = 0, (d) the linear acceleration of the particle labeled 3 at t = 0. (give answer in terms of m, g, d).



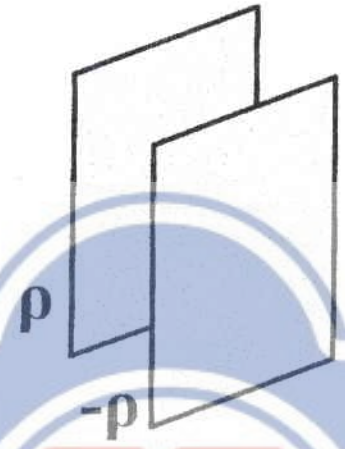
2. **(18%)**The water supply of a building is fed through a main pipe (水管) with area of 12 cm^2 in diameter. A faucet tap (水龍頭) with area of 4.00-cm^2, located 2.00 m above the main pipe, is observed to fill a 12.0-L container in 10.0 s. (a) What is the speed at which the water leaves the faucet? (b) What is the gauge pressure in the main pipe? Assume the faucet is the only "leak" in the building (the density of water $\rho=10^3$ kg/m^3 and the gravitation field g= 9.8 m/s^2).



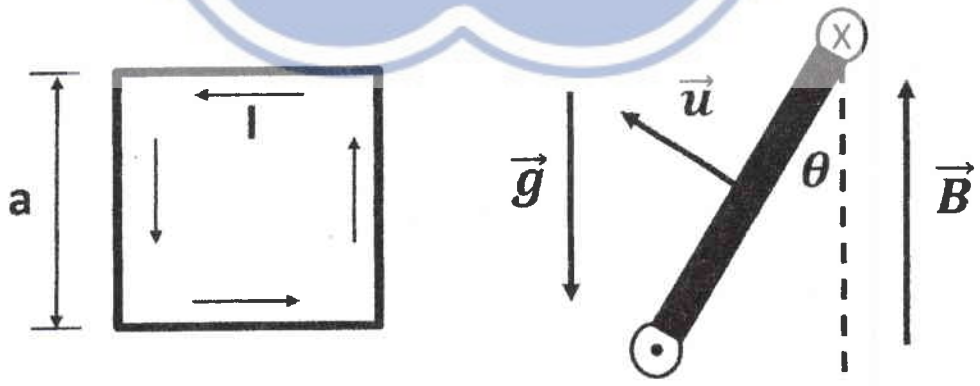
備註	一、作答於試題上者，不予計分。 二、試題請隨卷繳交。

考試科目	普通物理	系所別	應用物理研究所	考試時間	2 月 3 日(六) 第一 節

3. **(16%)**Two non-conducting plates are parallel to each other as shown in Figure. The plates have area, **A**, and distance between the palate is **d**. The plate on the left has a uniform surface charge density σ, and the one on the right has a uniform charge density $-\sigma$. Assume the area of the plate is far larger than the distance between the plates. Calculate the electric field (電場) at points (a) to the left of, (b) in between, and (c) to the right of the two sheets. (d) what is the capacitance (電容) of these two plates system. (give answer in terms of σ, A, d)



4. **(16%)** The square (正方形) loop of wire is fastened (固定) along one side so that the rest of the loop hang (懸掛) vertically in the gravitational field of Earth, g, but can rotate around the pivot (支點). The mass of the loop is **m** and the length of the side is, **a**. The loop carries a current **I** under a vertical uniform magnetic field **B**. The loop makes an angle **θ** with the vertical at rest. (a) what is the magnetic dipole moment (**u**) of this loop. (b) what is the amplitude and direction of the torque on loop by the magnetic field. (c) what is the amplitude and direction of the torque on loop by the gravitational force. (d) what is the relation of θ, I, a,B,m,g. (give answer in term of θ, I, a, B, m, g).

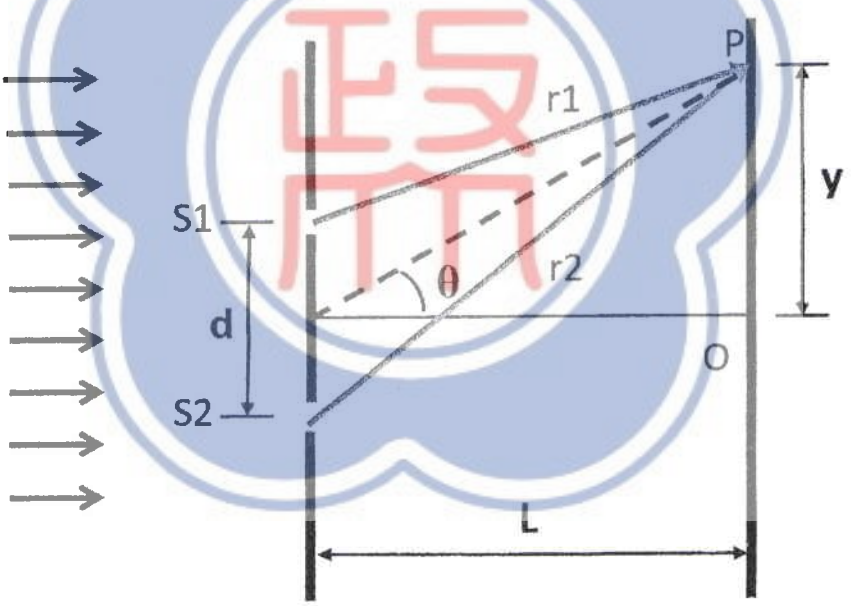


備註	一、作答於試題上者，不予計分。 二、試題請隨卷繳交。

考試科目	普通物理	系所別	應用物理研究所	考試時間	2月3日(六)第一節

5. **(18%)**A plane electromagnetic sinusoidal wave with electrical field described by the wave function: E = 600 cos (18.85x – 5.65×10^{9}t) (V/m), where x is in meters and t is in seconds. Determine for this wave (a) the frequency in Hz, (b) the angular wave number, k, (c) the wavelength, (d) the max amplitude of magnetic field in the EM wave. (e) write an expression for magnetic field *B(x,t)* with numerical values. (f) What is the intensity of this EM wave (average of poyting vector S_{avg}). Use $u_0 = 4\pi\times10^{-7}$.

6. **(16%)** In the figure, let L = 1.00 m and d = 0.10 mm and assume the slit system is illuminated with monochromatic 700-nm light. Calculate the phase difference between the two wave fronts arriving at P when (a) θ = 2° and (b) y = 3.50 mm. (c) What is the value of sin(θ) for which the path difference is λ/4? (d) what is the distance between two consecutive bright bands. (sin(2°)=0.035.).



備註	一、作答於試題上者，不予計分。 二、試題請隨卷繳交。

考試科目	近代物理	系所別	應用物理研究所	考試時間	2月3日(六)第二節

1. [*45 points*] **Short answer questions**

[5] (a) Two particles of the same mass m and moving at the same speed $v = 0.866c$ (c is the speed of light) collide head-on and combine to produce only a new particle of mass M. What is the mass of this new particle? (Note: At $v = 0.866c$, $\sqrt{1 - v^2/c^2} = 0.50$).

[5] (b) Consider two monochromatic (single-wavelength) light sources (light bulbs) emitting light of respective wavelengths λ_1 and λ_2, with $\lambda_2 > \lambda_1$. The two bulbs are otherwise identical and emit light with exactly the same intensity (in W/m^2). A detector placed a distance d from bulb 1 (emitting at wavelength λ_1) records N photons per second. When the same detector is placed at the same distance d from bulb 2 (emitting at wavelength λ_2), is the number of photons per second recorded by the detector greater than N, smaller than N, or equal to N? EXPLAIN YOUR ANSWER.

[5] (c) Some stars are observed to be reddish, and some are blue. Which stars have the higher surface temperature? Explain.

[5] (d) An electron is trapped in a one-dimensional region of space between two rigid walls at $x = 0$ and $x = L$. In the first excited state, where would you expect that the electron is most likely found?

[5] (e) A particle in an infinite square well has as its initial wave function an equal mixture of he first three orthonormal stationary states:

$$\Psi(x, 0) = A\left[\varphi_1(x) + \varphi_2(x) + \varphi_3(x)\right].$$

What is the value of the normalization constant A?

[6] (f) (i) Write out the electronic configuration for oxygen ($Z = 8$). (ii) Write out the values for the set of quantum numbers n, ℓ, m_ℓ, and m_s for each of the electrons in oxygen.

[9] (g) Consider a collection of 4 *identical* atoms obeying the rules of quantum mechanics. The atoms can occupy a set of energy levels at 2 eV, 4 eV, 6 eV and 8 eV. At a temperature of $T = 0\,\mathrm{K}$, what would be the *average energy* of these 4 atoms if they behaved like:

(i) spin-1 particles,

(ii) spin-1/2 particles,

(iii) spin-1/2 particles in a strong magnetic field in which all the electron spins point in the same direction.

Give your answers in units of eV.

[5] (h) A certain insulator has an energy gap of 6.0 eV. Is this insulator opaque or transparent to visible light. EXPLAIN YOUR ANSWER.

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考試科目	近代物理	系所別	應用物理研究所	考試時間	2月3日(六)第二節

2. [*15 points*] **Relativity**

An observer in frame S sees lightning simultaneously strike two points 100 m apart. The first strike occurs at $x_1 = y_1 = z_1 = 0$ at time $t_1 = 0$ and the second at $x_2 = 100\,\text{m}$, $y_2 = z_2 = 0$ at time $t_2 = 0$.

(a) What are the coordinates of these two events in a frame S' moving in the standard configuration at $0.70c$ relative to S?

(b) How far apart are the events in S'?

(c) Are the events simultaneous in S'? If not, what is the difference in time between the events, and which event occurs first?

3. [*20 points*] **The quantum oscillator**

The wavefunction

$$\psi(x) = Cxe^{-\alpha x^2}$$

describes a state of the quantum oscillator in a potential energy $U(x) = m\omega^2 x^2/2$.

(a) Using Schrödinger's equation, obtain an expression for α in terms of the oscillator mass m and the frequency ω.

(b) What is the energy of this state?

4. [*20 points*] **Expectation value**

An electron is described by the wavefunction

$$\psi(x) = \begin{cases} 0 & \text{for } x < 0 \\ Ce^{-x}(1 - e^{-x}) & \text{for } x > 0, \end{cases}$$

where C is a constant.

(a) Find the value of C that normalizes ψ.

(b) Where is the electron most likely to be found; that is, for what value of x is the probability for finding the electron largest?

(c) Calculate the average position $\langle x \rangle$ for this electron.

備註	一、作答於試題上者，不予計分。 二、試題請隨卷繳交。