國立中正大學九十二學年度碩士班招生考試試題

系所別：機電光整合工程研究所　　科　目：物理

物理含工程力學（靜力與動力學）、電學、光學及熱流（熱力與流體力學）四大部分，考生必須自行選擇其中一大部分作答。

工程力學

1. Determine the components of all joint forces on member of the frame shown in Figure 1. (25%)

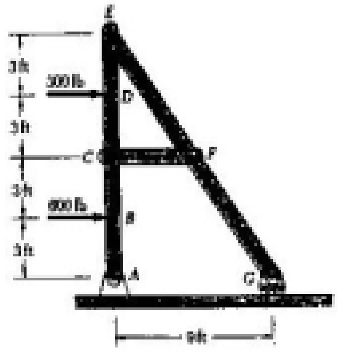


Figure 1

2. Knowing that the friction coefficient $\mu = 0.2$ at all surface of contact. If the plate A is 20 kg and the plate B is 10 kg, determine the magnitude of the force P required to move the plate B to the left. (Neglect bearing friction in the pulley) (25%)

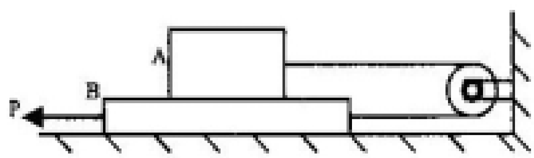


Figure 2

國立中正大學九十二學年度碩士班招生考試試題

系所別：機電光整合工程研究所　　科　目：物理

3. A disk of radius R rolls on the plane surface with a constant counterclockwise angular velocity of ω as shown in Figure 3. Bar AB of length L slides on the surface of the disk at A. Determine the angular velocity ω_{AB} of bar AB. (25%)

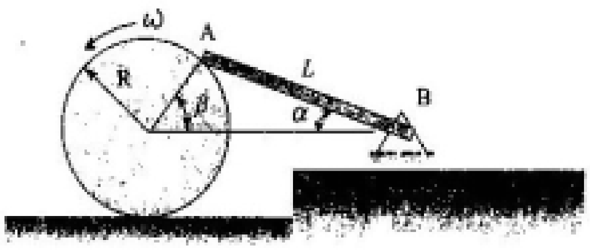


Figure 3

4. A nonrotating slender bar A moving with velocity v_0 strikes a stationary slender bar B as shown in Figure 4. Each bar has mass m and length L. If the bars adhere when they collide, what is their angular velocity after the impact? (25%)

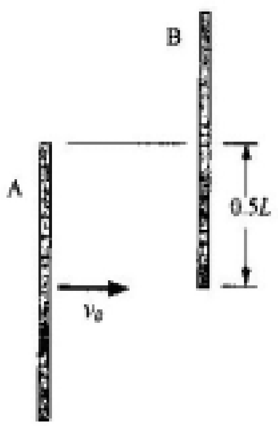


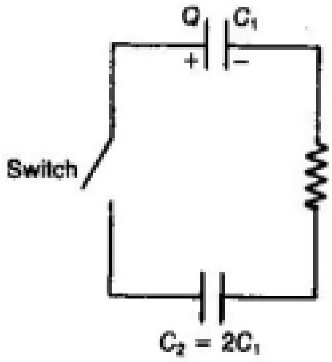
Figure 4

國立中正大學九十二學年度碩士班招生考試試題

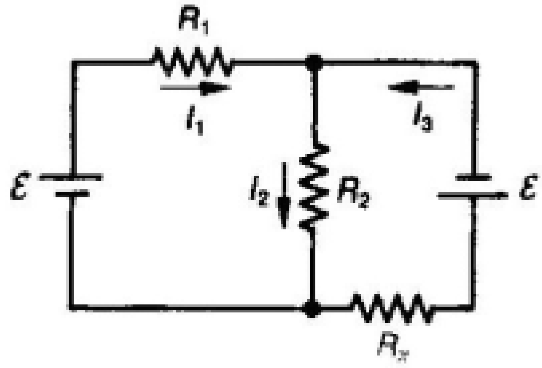
系所別：機電光整合工程研究所　　科　目：物理

電學

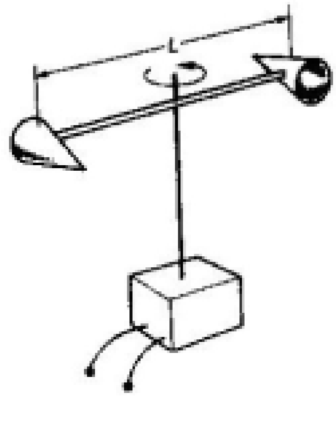
1. Two capacitors C_1 and $C_2 = 2C_1$ are connected in a circuit with a switch between them (see Figure). Initially the switch is open and C_1 holds charge Q. The switch is closed and the system relaxes to a steady state. Find the potential V, electrostatic energy U and charge for each capacitor. Compare the total electrostatic energy before and after closing the switch, expressed in terms of C_1 and Q. (15%)



2. Consider the circuit shown below. R_x is a variable resistor, and the internal resistance of the batteries is negligible. If the emfs ε of the batteries are 6 V and $R_1 = R_2 = 2\ \Omega$, express the current I_2 in the resistor R_2 in terms of R_x. Is there a value R_x for which this current vanishes? (15%)



3. A device for measuring wind speed has two conical cups attached to a horizontal rod of length $L = 0.5$ m (see Figure). The rod is attached to a vertical axle, which rotates a vertical conducting wire loop of area $A = 0.1\ m^2$ and $N = 200$ turns. The Earth's magnetic field has horizontal component $B = 10^{-4}$ T at this point. Find the maximum voltage induced by a wind of speed $v = 100$ km/h, assuming that the cups rotate at exactly this speed. (10%)



4. A beam of electrons is injected horizontally with velocity $v_e = 10^6$ ms^{-1} into a vacuum tube in which there is a constant electric field $E_o = 2000$ NC^{-1} directed vertically upwards. At the end of the tube the beam hits a fluorescent screen $h = 10$ cm lower than the injection point. (10%)
   (a) If the polarity of the field is reversed, what happens to the impact point?
   (b) What is the horizontal distance ℓ between the injection point and the screen?

5. Three unknown charges q_1, q_2, and q_3 exert forces on each other. When q_1 and q_2 are 15.0 cm apart (q_3 is absent), they attract each other with a force of 1.4×10^{-2} N. When q_2 and q_3 are 20.0 cm apart (q_1 is absent), they attract with a force of 3.8×10^{-2} N. When q_1 and q_3 are 10.0 cm apart (q_2 is absent), they repel each other with a force of 5.2×10^{-2} N. Find the magnitude and sign of each charge. (10%)

6. A thin, circular disk of radius R is oriented in the xy-plane with its center at the origin. A charge Q on the disk is distributed uniformly over the surface. (15%)
   (a) Find the electric field due to the disk at the point $z=z_0$ along z-axis.
   (b) Find the field in the limit that $z_0\to+\infty$.
   (c) Find the field in the limit that $R\to\infty$.

7. A straight solenoid of diameter 5 cm and length 25 cm is wrapped with 200 turns of wire that carries a current of 5 A. The solenoid is filled with a material of magnetic susceptibility $\chi_m=10^{-5}$. (15%)
   (a) Find the magnetic intensity within the solenoid.
   (b) Find the magnetic field within the solenoid.
   (c) By what factor is the magnetic field changed due to the presence of the material?

8. There is an AC source of emf in a single-loop circuit that produces a potential drop in the form $V(t)=V_0\sin(\omega t)$, while the current in the circuit takes the form $I(t)=I_0\sin(\omega t-\phi)$. Make a phasor diagram for the current and potential drop across each element if the circuit contains (10%)
   (a) a resistor and a capacitor.
   (b) a resistor and an inductor.

科目：光學（總分100分）

1. Light that has a wavelength 800 nm in air is incident at angle of 30^0 to the normal of a plate of heavy flint glass of the refractive index 2. See Fig.1. Assume the refractive index of air is 1.
   (a) Find the angle of refraction (5%),
   (b) the wavelength of glass (5%),
   (c) the speed of light in the glass (5%).

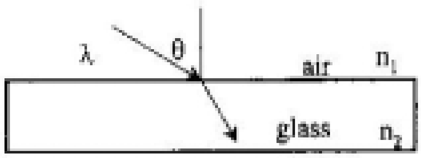


Fig. 1

2. (a) Write down the equation governing thin lenses and thin spherical mirrors. Take p=distance of object, q=distance of image, f=focal length, and distances are measured to the lens or mirror along the symmetry axis.(5%)
   (b) From the mirror formula, determine where the object be placed if the image is to be the same size as the object. Assume the focal length of the concave mirror is f. (5%)

3. (a) What is the lensmaker's equation (see Fig.2) ? (5%)
   (b) Two lenses, each of focal length +10cm, are in contact. Find the focal length of the combination. (5%)

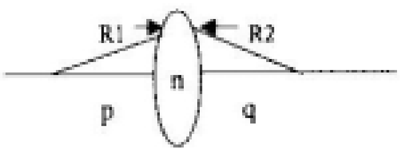


Fig. 2

4. An optical fiber is a thin, transparent, flexible strand that consists of a core surrounded by cladding, as shown in Fig.3. The refractive indexes of the core and the cladding are n_1 and n_2, respectively. Assume the surrounding medium has index n_0. Show that the maximum angle θ at which light will undergo total internal reflection is given by

$$\sin\theta = \frac{\sqrt{n_1^2 - n_2^2}}{n_0} \quad (15\%)$$

Fig. 3

國立中正大學九十二學年度碩士班招生考試試題

系所別：機電光整合工程研究所　　科　目：物理

5. (a) What is Rayleigh criterion?
   (b) Calculate the resolving power of a grating with N grooves (slits). (12%)

6. (a) What is Michelson interferometer?
   (b) Explain how to use Michelson interferometer to measure the thickness of a uniform object with a refractive index n. (14%)

7. A plane light wave (wavelength = λ) is incident on a glass wedge as shown in figure below (Fig.4). Find the spacing of the bright fringes on the screen. (Assume the difference of the refractive index between air and glass is negligible.) (12%)

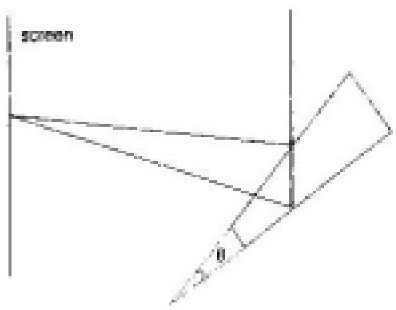


Fig. 4

8. If we want to design an anti-reflection coating for normal incidence lights on a lens (n = 1.52) by coating the surface of the lens with a thin film of MgF_2 (n = 1.38), what is the minimum thickness of the thin film for a light of wavelength 550 nm? (12%)

Fig. 5

熱流

1. Please explain the physical meanings of (a) lift coefficient, (b) Reynolds number, (c) potential flow, (d) momentum thickness and (e) friction factor. **(5% each)**

2. A laminar boundary layer velocity profile is approximated by $u/U = [3-2(y/\delta)](y/\delta)$ for $y \le \delta$ and $u = U$ for $y > \delta$. Please show that this profile satisfies the appropriate boundary conditions **(10%)** and determine the drag at the wall **(10%)** and momentum thickness **(5%)**

3. Air undergoes two processes in series:
   Process 1–2: polytropic process, $pv^{1.3}$ = constant, from p_1 = 100kPa, v_1 = 0.04 m^3/kg, to v_2 = 0.02 m^3/kg
   Process 2–3: constant pressure process to $v_3 = v_1$
   (a) Sketch the processes on a *p-v* diagram and determine the work per unit mass of air, in kJ/kg. **(5%)**
   (b) The total work of the whole process, in kJ/kg. **(10%)**

4. Electronic components are mounted on the inner surface of a horizontal cylindrical duct whose inner diameter is 0.2 m, as shown in Fig. 1. To prevent overheating of the electronics, the cylinder is cooled by a stream of air flowing through it and by convection from its outer surface. Air enters the duct at 25°C, 1 bar and a velocity of 0.3m/s and exits with negligible changes in kinetic energy and pressure at a temperature that cannot exceed 40°C. If the electronic components require 0.20kW of electric power, determine the minimum rate of heat transfer by convection from the cylinder's outer surface, in kW, for which the limit on the temperature of the exiting air is met. (Assume the air behaves as an ideal gas, h(40°C) = 313.3 kJ/kg, h(25°C) = 298.2 kJ/kg) **(15%)**

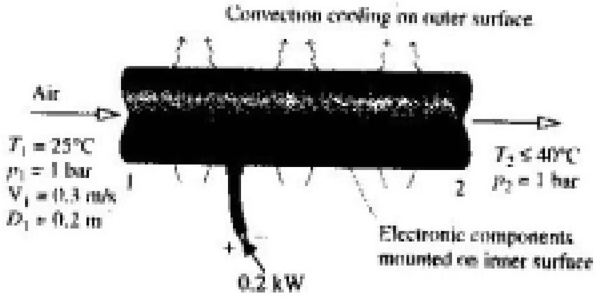


Fig. 1

5. Referring to Fig. 2, air is confined to one side of a rigid, insulated container divided by a partition. The other side is initially evacuated. The following data are known for the initial state of the gas: $p_1 = 3$ bar, $T_1 = 380$K, and $V_1 = 0.025\text{m}^3$. When the partition is removed, the gas expands to fill the entire container and achieves a final equilibrium pressure of 1.5 bar. Assuming air behaves as an ideal gas and with constant specific heats, determine

(a) the final temperature, in K. **(10%)**

(b) the final volume, in m^3. **(5%)**

(c) the entropy production, σ, in kJ/kg. **(5%)**

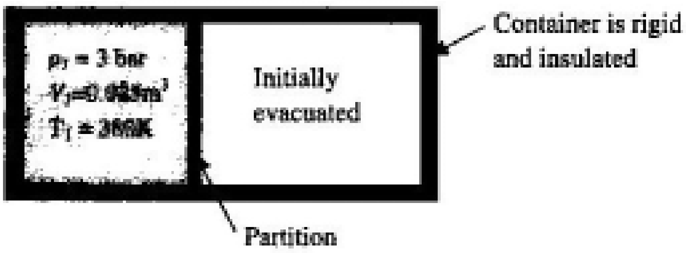


Fig 2