

科目：普通物理(3002) 校系所組：中大物理學系、天文研究所

交大電子物理學系丙組、物理研究所

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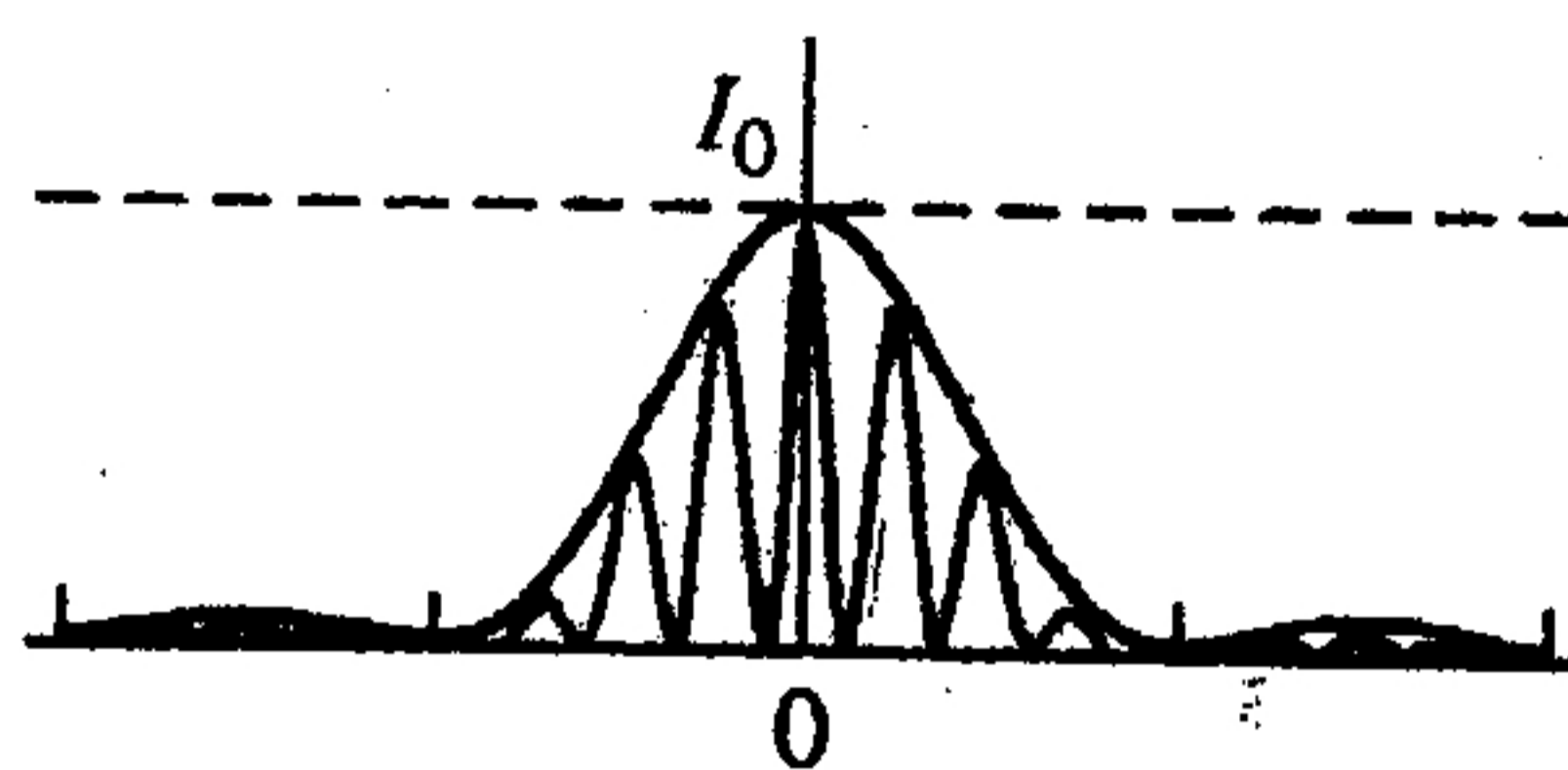
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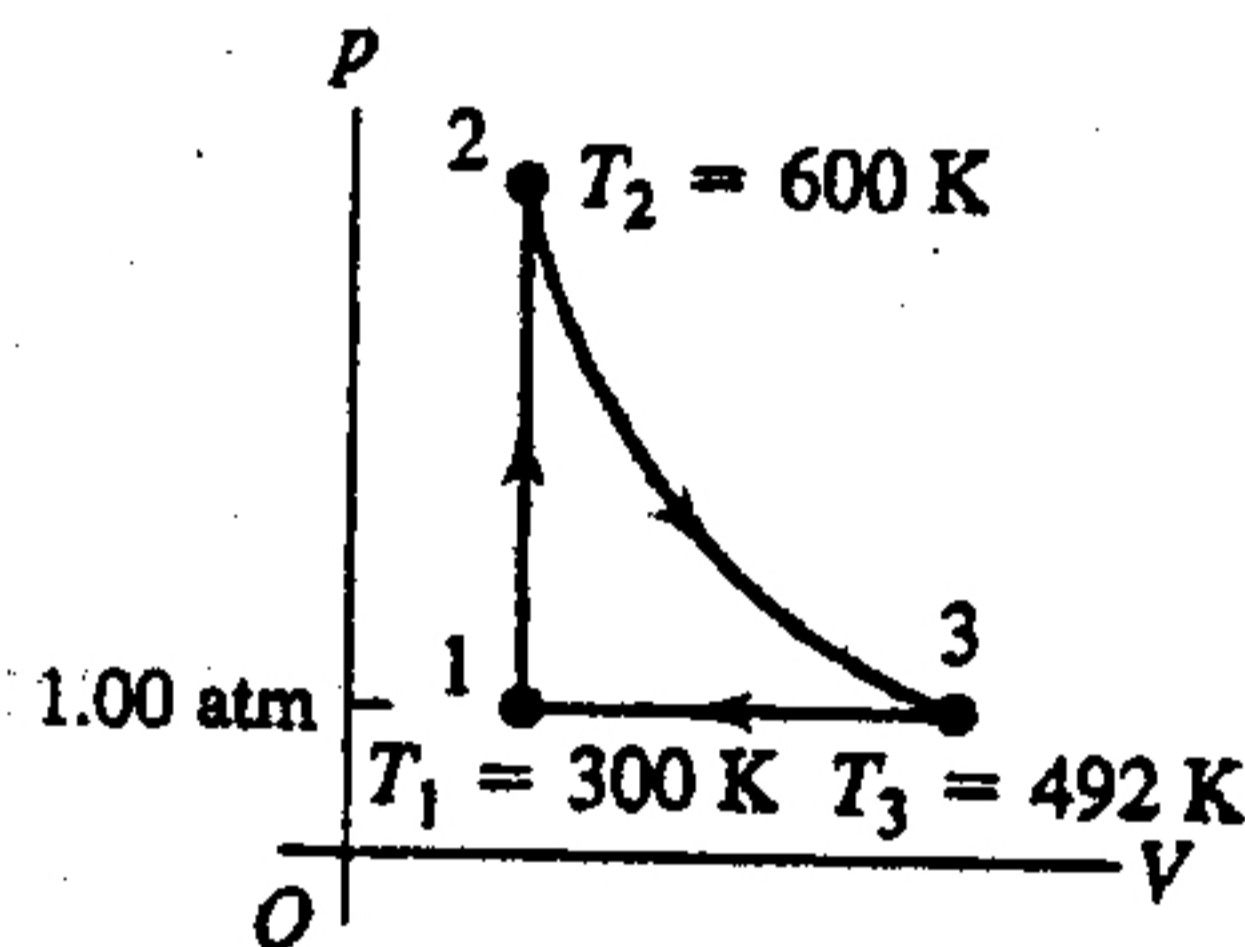
參考用

Part I 填充題 (每格 3 分, 共 60 分)

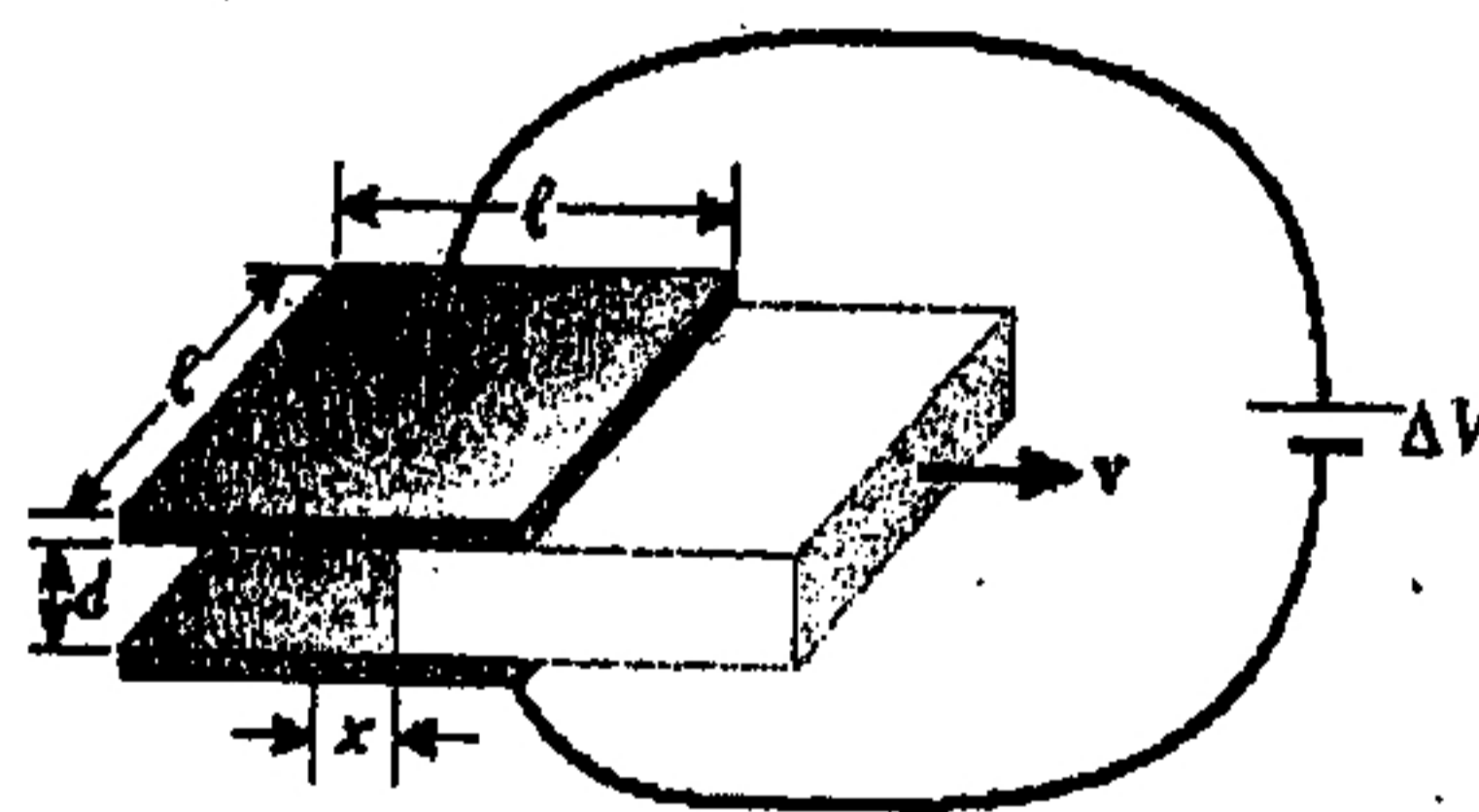
633-nm He-Ne laser light is passed through two slits of finite width and the diffraction pattern on a screen 6.0 m away is observed. The diffraction pattern is as shown. The distance between two adjacent interference maxima is 4.0 mm. The width of the slit is (1) and the distance between the slits is (2).



A heat engine takes 0.350 mol of a diatomic ideal gas around the cycle shown in the pV -diagram. Process 1 \rightarrow 2 is at constant volume, process 2 \rightarrow 3 is adiabatic, and the process 3 \rightarrow 1 is at a constant pressure of 1.00 atm. The value of γ of this gas is 1.40. (a) The net work done by the gas in the cycle is (3). (b) The net heat flow into the engine in one cycle is (4). (c) The thermal efficiency of the engine is (5).

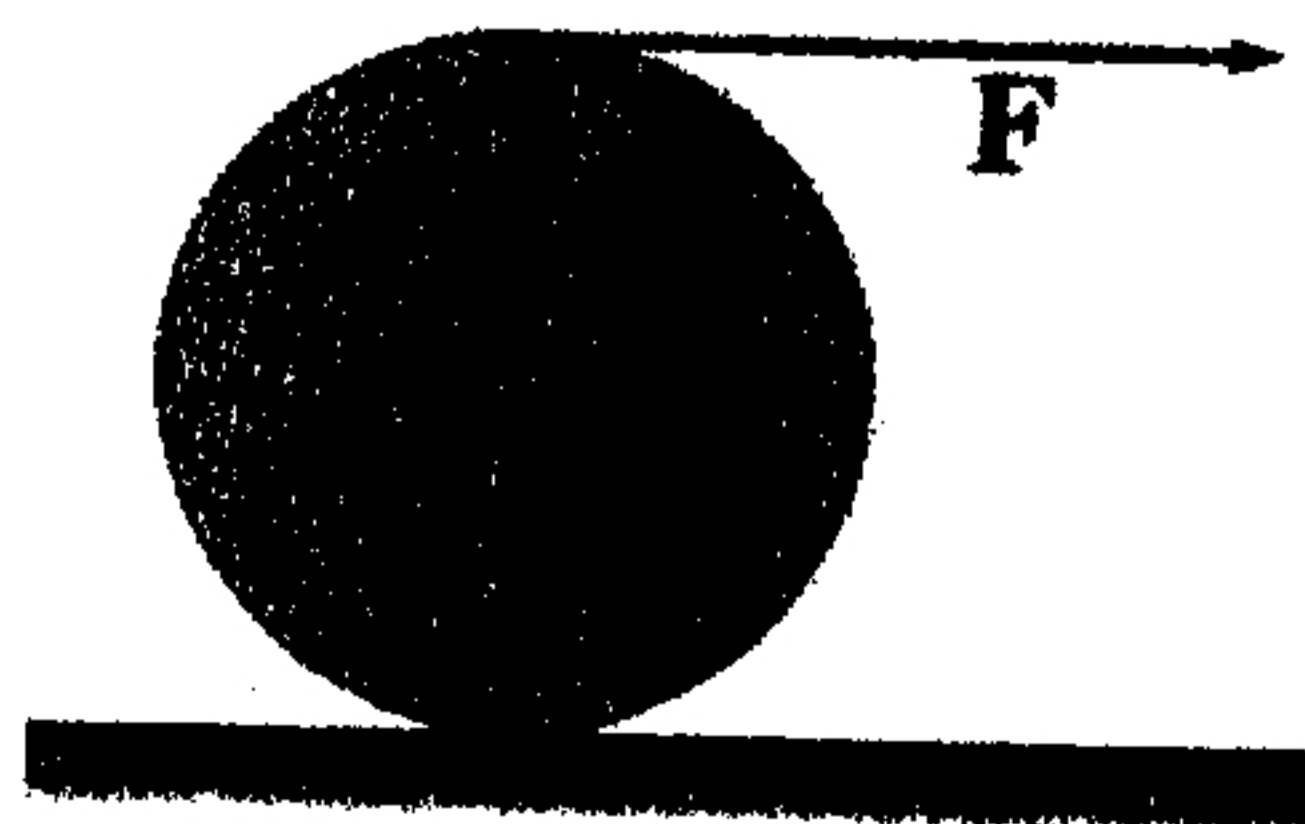


A parallel-plate capacitor consists of square plates of edge length ℓ that are separated by a distance d , where $d \ll \ell$. A potential difference ΔV is maintained between the plates. A material of dielectric constant κ fills half of the space between the plates. The left edge of the dielectric is at a distance x from the center of the capacitor. The dielectric slab is now withdrawn from the capacitor at a constant speed v . what is the current (6) in the circuit as the dielectric is being withdrawn?



A block with mass M attached to a horizontal spring with a force constant k is moving with simple harmonic motion having amplitude A . At the instant when the block moves to one end of its path, a lump of putty with mass m is dropped vertically onto the block from a negligible height and sticks to it. Find the new amplitude (7) and new period (8).

A spool of wire of mass M and radius R is unwound under a constant force F . Assuming the spool is a uniform solid cylinder that doesn't slip, (a) the acceleration of the center of mass is (9) and (b) the force of friction is to the *right* and equal in magnitude to (10).



注意：背面有試題

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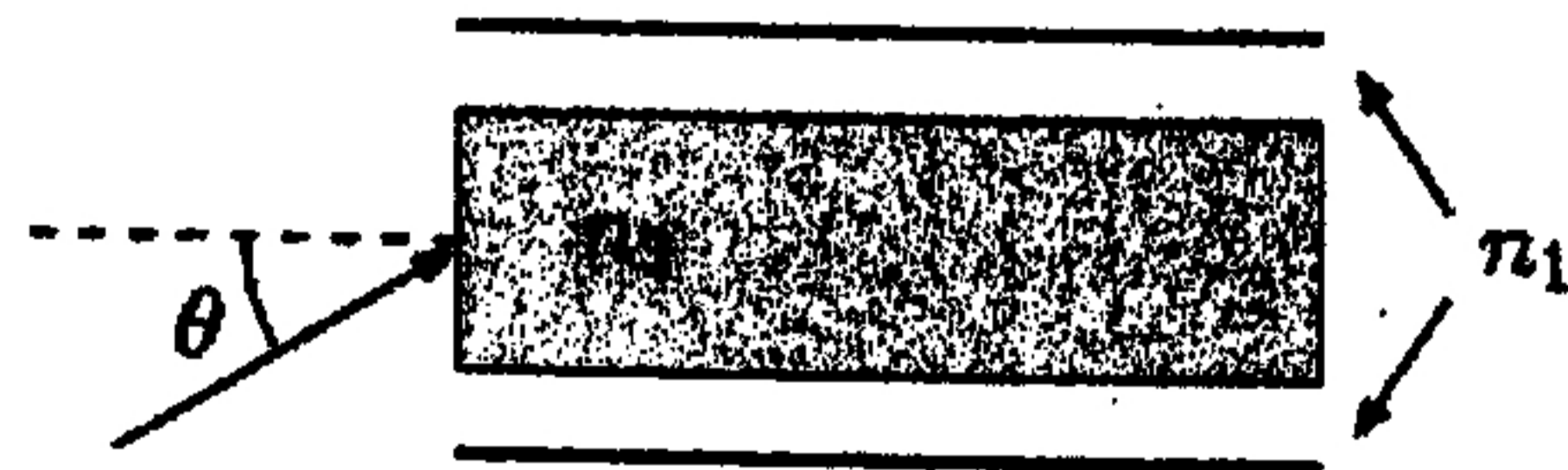
氫原子的游離能是 $E_H = 13.6 \text{ eV}$. 若現在有一個電荷為 $+e$ 的粒子和一個電子組成的系統, 其游離能是 $E_I = 3E_H/4$, 則此帶正電粒子的質量 = (11) (以電子質量 m_e 及質子質量 m_p 表示).

當高能宇宙射線打在地球大氣層上層邊界時可以產生許多 μ 粒子, 其質量為 m_μ , 有非常短的半衰期 $\tau_\mu = 2.2 \times 10^{-6} \text{ s}$. 若假設 μ 粒子被產生出來後以接近光速 c 的速度向地表移動, 若我們要能在地球表面上觀察到 μ 粒子, 其在地球大氣層上方產生時的最小的初始能量 $E_\mu =$ (12) ? (以 c, m_μ, τ_μ , 及大氣厚度 L 表示).

一個太陽能熱水器有個面積 1 m^2 的拋物面反射鏡, 可以把陽光聚焦在一加熱點. 假設在某處, 地表太陽輻射功率為 600 W/m^2 . 而此熱水器的光熱轉換效能為 50%, 需要多少 (13) 小時, 才能把原來 20° C 一公升的水完全煮乾? (估計到小數點下一位). 若現在把水換成不會熔化的理想黑體, 有任意長的時間可以運作. 此理想黑體可達到最高的溫度是 (14) ? (設太陽表面溫度 $= 5500 \text{ K}$, 太陽半徑為 $7 \times 10^8 \text{ m}$, $1 \text{ AU} = 1.5 \times 10^{11} \text{ m}$, $\sigma = 5.67 \times 10^{-8} \text{ Wm}^{-2} \text{ K}^4$)

假設一根中空管子的前後端各有一線性偏極片, 這兩塊的偏極方向互相垂直. 假設你被允許在管子中段另外插入兩片線性偏極片, 則透過此管子看原先強度為 I_0 的非極化光源, 你可觀察到最大的亮度是 (15) ?

光纖是由兩層折射係數不同的同心柱狀結構介質包覆組成 ($n_1, n_2 > 1$). 它要能夠傳遞光訊號的條件是 (16) ? 又, 光訊號由空氣 ($n=1$) 入射, 可在此光纖中傳遞的最大入射角 $\theta =$ (17) ?



一個非導電圓盤其半徑為 R , 表面電荷密度為 σ ($\sigma > 0$). 則在其圓心正上方高度為 h 的電位 $V(z) =$ (18) ? (用 R, z, σ , 及 ϵ_0 表示.) 若有一個質量為 m , 電荷為 q ($q > 0$) 的粒子, 由圓心正上方無窮遠處以速度 v 向下入射. 不考慮重力, 它可以最接近此圓盤的距離為 (19) ? 現在, 我們用一條不導電, 彈力係數為 k , 質量為零的彈簧, 連接此帶電粒子及圓盤圓心. 若一開始, 此帶電粒子停在一平衡點 $h = h_0$, 當我們給它一個極小的擾動 ($\Delta h \ll h_0$), 它的振盪角頻率 $\omega =$ (20) ? (使用 SI 單位).

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參考用

Part II 計算題：須寫下詳細的計算過程 (共 40 分)

1. A satellite moves around the Earth in a circular orbit of radius r .

(a)[2%] What is the speed v_0 of the satellite?

Suddenly, an explosion breaks the satellite into two pieces, with masses m and $4m$. Immediately after the explosion the smaller piece of mass m is stationary with respect to the Earth and falls directly toward the Earth.

(b)[3%] What is the speed v_1 of the larger piece immediately after the explosion?

(c)[5%] Because of the increase in its speed, this larger piece now moves in a new elliptical orbit. Find its distance (expressed in terms of r) away from the center of the Earth when it reaches the other end of the ellipse.

(Note: You may use square root and rational numbers to express the answers).

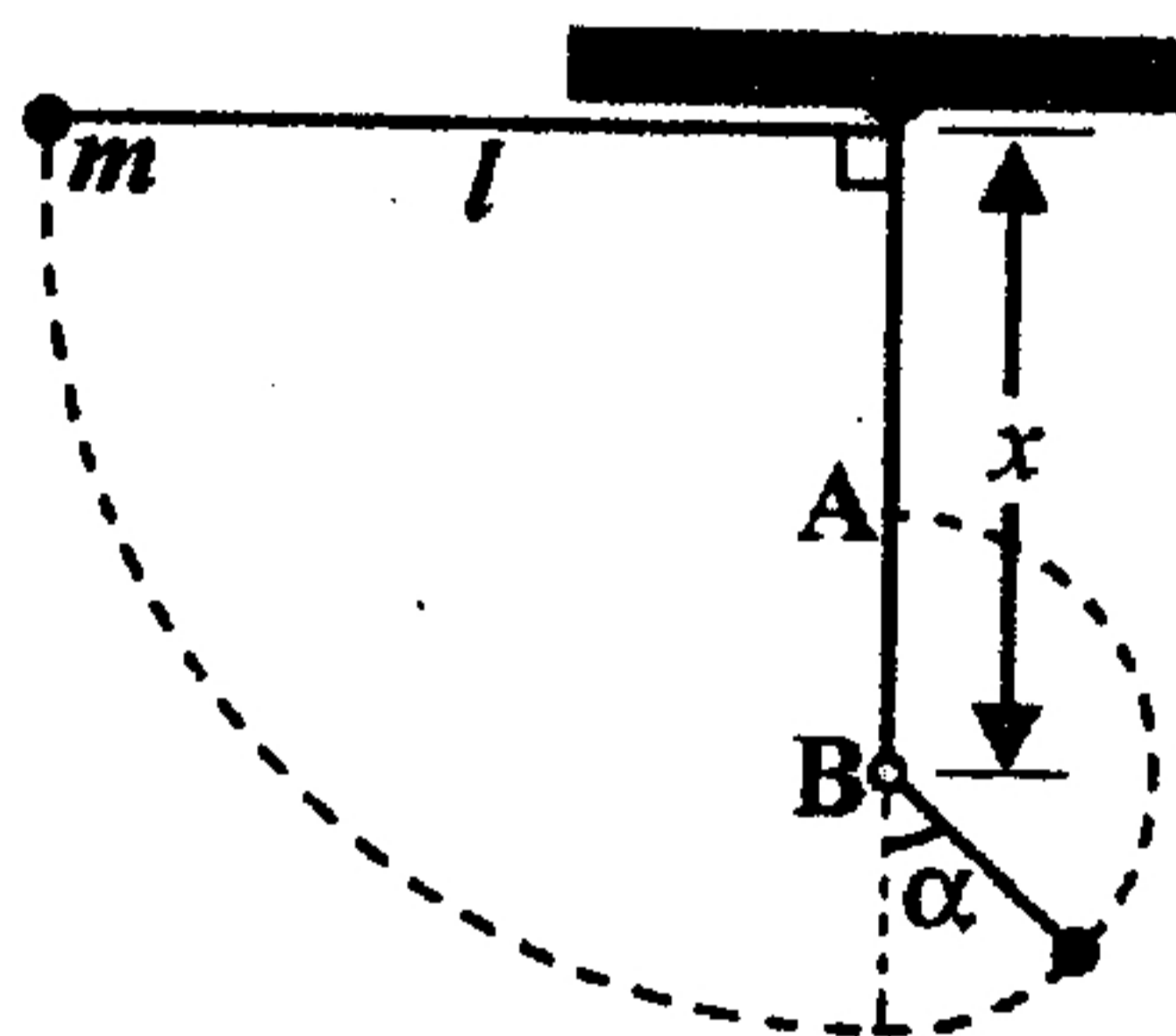
2. A pendulum of rope length l has a bob of mass m . Its motion is interrupted by a peg at point B that is vertically beneath the support at a distance x . The bob is released horizontally.

(a)[3%] What is kinetic energy of m at angle α in the figure?

(b)[3%] What is the tension in the rope at point A?

(c)[4%] Find the minimum value of x such that m can swing in a complete circle centered on B.

Express the answers in terms of α , x , m , l , and g .



3. 一個實心非導電球體，半徑為 R ，質量為 M ，帶總電荷 Q ，其電荷均勻分佈在整個球體，在外太空以角速度 ω 自旋。求

(a) [2%] 其轉動慣量(rotational inertia).

(b) [4%] 所產生的磁偶極(magnetic dipole moment)大小。

(c) [4%] 若把它放置在一個均勻磁場 B 內，且此磁場的方向不平行於球體的自旋方向。求其自轉軸進動(precession)的角速度。

(使用 SI 單位)

4. 一個實心球體，在半徑 $0 \leq r \leq R_1$ 有體密度為 ρ ($\rho > 0$) 的電荷分佈，而在半徑 $R_1 \leq r \leq R_2 = 2^{1/3} R_1$ 處有體密度為 $-\rho$ 的電荷分佈。

(a) [5%] 求電位 V 對 r 的函數 $V(r)$ 。

(b) [5%] 若在此球面一端挖一條通過球心的隧道抵達另外一端的球面。把一個質量為 m ，電荷為 $-q$ ($q > 0$) 的質點，用繩子吊放在此隧道 $r = R_1/2$ 處。然後放開，讓它沿隧道自由運動，若不考慮萬有引力，求其震盪週期。

(使用 SI 單位)