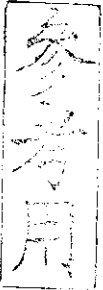科目：普通物理(3002) 　校系所組：中大物理學系、天文研究所
交大電子物理學系丙組、物理研究所
清大物理學系、先進光源科技碩士學位學程甲組、天文研究所
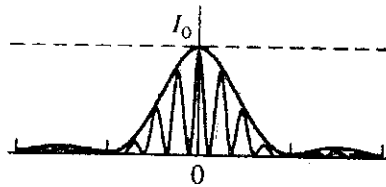陽明生物醫學影像暨放射科學系生物醫學影像組
陽明生醫光電工程研究所理工組 A

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)__ .
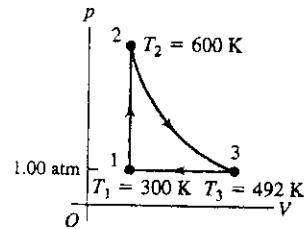
A parallel-plate capacitor consists of square plates of edge length ℓ that are separated by a distance d, where $d \ll \ell$. A potential difference ΔV is maintained between the plates. A material of dielectric constant κ fills half of the space between the plates. The left edge of the dielectric is 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 The dielectric slab is now withdrawn from the capacitor at a constant speed v. what is the current __(6)__ in the circuit as the dielectric is being withdrawn?
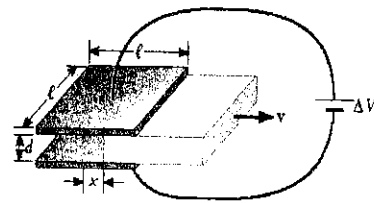
A block with mass M attached to a horizontal spring with a force constant k is moving with simple harmonic motion having amplitude A. At the instant when the block moves to one end of its path, a lump of putty with mass m is dropped vertically onto the block from a negligible height and sticks to it. 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)__ .
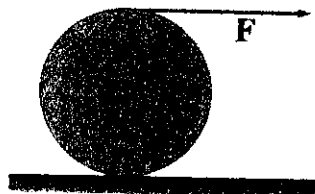
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陽明生物醫學影像暨放射科學系生物醫學影像組

陽明生醫光電工程研究所理工組A

氫原子的游離能是 E_H =13.6 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 τ_μ =2.2x10⁻⁶ 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_μ = ___(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 1m² 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/m². 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=5500K, 太陽半徑為 7x10⁸m, 1AU=1.5x10¹¹m, σ =5.67x10⁻⁸ Wm⁻²K⁴)

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 θ = ___(17)___ ?
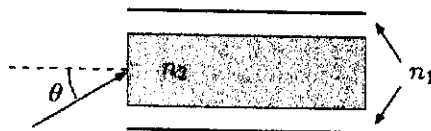
一個非導電圓盤其半徑為 R, 表面電荷密度為 σ (σ >0). 則在其圓心正上方高度為 h 的電位 V(z)= ___(18)___ ? (用 R, z, σ, 及 ε_0 表示.) 若有一個質量為 m, 電荷為 q (q>0) 的粒子, 由圓心正上方無窮遠處以速度 v 向下入射. 不考慮重力, 它可以最接近此圓盤的距離為 ___(19)___ ? 現在, 我們用一條不導電, 彈力係數為 k, 質量為零的彈簧, 連接此帶電粒子及圓盤圓心. 若一開始, 此帶電粒子停在一平衡點 h= h_0, 當我們給它一個極小的擾動 ($\Delta h \ll h_0$), 它的振盪角頻率 ω = ___(20)___ ? (使用 SI 單位).

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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_i 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.
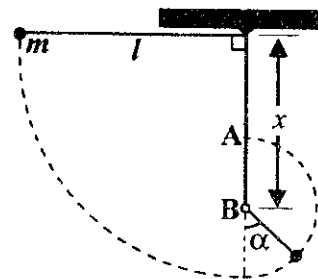
3. 一個實心非導電球體, 半徑為 R, 質量為 M, 帶總電荷 Q, 其電荷均勻分佈在整個球體, 在外太空以角速度 ω 自旋. 求
(a) [2%] 其轉動慣量(rotational inertia).
(b) [4%] 所產生的磁耦極(magnetic dipole moment)大小.
(c) [4%] 若把它放置在一個均勻磁場 B 內, 且此磁場的方向不平行於球體的自旋方向. 求其自轉軸進動(precession) 的角速度.
(使用 SI 單位)

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