計算與問答題(十大題)

1. (10 %) Consider a uniform rope with density ρ subject to a tension force T. Derive the wave equation for the transverse wave of the small amplitude. (Let us call the displacement $y(t, x)$, and x is the coordinate along the rope.)

2. (10 %) Consider a helium balloon with negligible mass in the bus with all windows closed. When the bus is accelerating in $a=ai$, where i is the unit vector in the positive x direction, describe the status of the balloon and explain the reason. If we consider the massive balloon, does your answer change? Explain the reason. (Status: Does it tilt or not? What are the tilting direction and angle?)

3. (10 %) The temperature dependence of the molar specific heat in the metal is given by $C_v = AT+BT^3$ as T is low, where A and B are constants different from materials to materials. Suppose that the entropy for the metal is zero at T=0, calculate the entropy for the metal of n mol at $T = T_f$.

4. (10 %) Three waves, $g_1(x,t)=Csin(kx+\omega t +\pi/12)$, $g_2(x,t)=Csin(kx+\omega t +7\pi/12)$, and $g_3(x,t)=Csin(kx+\omega t +5\pi/6)$, are to be sent on the same rope. They interfere with one another. Calculate the amplitude of the resultant wave.

5. (10 %) Consider a bucket quarter filled with oil. When the bucket is rotating with the angular velocity ω, derive the equation of the surface $h(x)$, where h is measured from the lowest of the surface and x is measured from the rotational axis. Does it change if we replace oil by water?

6. (10 %) (a) Consider a dipole $\vec{P}$ is placed in a uniform electric field $\vec{E}$, what is the net force and toque on the dipole .(b)Suppose a dipole $\vec{P}$ is placed in a nonuniform electric field $\vec{E}(x) = E(x)\hat{i}$ that points along the x axis. If $\vec{E}(x)$ depends only on x, show that the net force on the dipole is $\vec{F} = \left(\vec{p} \cdot \dfrac{d\vec{E}}{dx} \right)\hat{i}$.

7. (8 %) (a)The *homopolar generator* consists of a rotating conducting disk, one electrical brush sliding contact at its axle and another contact on its circumference (as Figure). A magnetic field, B, is applied perpendicular to the disk, with a radius of r and the angular speed of ω. Find the emf generated between two brushes. (b) The *homopolar generator* is a low-voltage, high-current electric generator. What if a voltage is applied to the brushes, can it run in reverse to play as a *motor*? (Explain why).

8. (8 %) Lasers have been used to suspend spherical glass beads against the gravitational field. (a) If a black bead has a mass m and a density ρ. Determine the radiation intensity needed to support the bead. (b) Describe possible applications of the laser trap. [For example, the "laser trap assay technique" is used to measure the molecular forces (piconewtons) generated by a single myosin motor as it interacts with a single actin filament.]

9. (12 %) Photonic crystals, such as opal, are composed of periodic dielectric nanostructures that affect the propagation of electromagnetic waves. As well, iridescent peacock feathers are composed of transparent keratin that supports melanin rods in a regular lattice. (a) Explain how this structure can appear blue-green when it contains no blue or green pigment. Assume that the melanin rods are uniformly separated by 0.25 μm, with air between them. (b) Explain how it can also appear violet if light falls on it in a different direction. (c) A compact disc can appear to be any color of the rainbow. Why the feather cannot appear yellow or red.

10. (12 %) (a) What is "Quantum Physics"? Does the Quantum Physics have to be based on "experimental evidence" or "theoretical deduction"? (b)Describe the Franck-Hertz Experiment and its physic significance. (c) Describe the essentials of Quantum Physics, and construct a "Concept Map(概念圖)". (Right figure shows an example of the Concept Map for Electromagnetism)
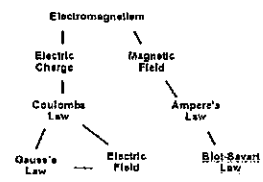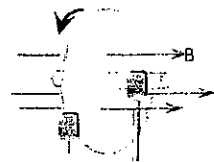
Example of Concept Map for Electromagnetism

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