Physics (2006)

1. (25 pts) An inclined plane that makes an angle of 28° to the horizontal is mounted on wheels. A small block of mass m = 1 kg rests on the plane, held there by a coefficient of static friction μ = 0.75. The plane is accelerating to the right as shown. What is the minimum acceleration in order that the block slides down the plane?

2. (25 pts) Electric dipole: a pair of charges lie in the x-y plane. The charge +q is at coordinate x = 0, y = b; the charge −q is at coordinate x = 0, y = −b as shown in the figure below. Let $\vec{E}(\vec{r}) = (E_x(\vec{r}), E_y(\vec{r}), E_z(\vec{r}))$ be the electric field at the point of coordinate $\vec{r} = (r_x, r_y, r_z)$. Evaluate $\vec{E}_x(\vec{r})$.
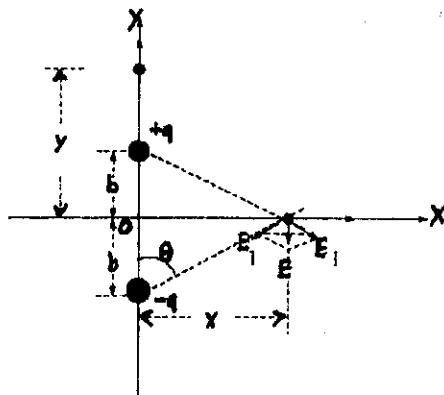
3. (20 pts) Let 1.00 kg of liquid water at 100℃ be converted to steam at 100℃ by boiling at standard atmospheric pressure, which is 1.00 atm = 1.01×10^5 Pa. The volume of that water changes from $1.00 \times 10^{-3} m^3$ to $1.67 m^3$. It is known that the heat of vaporization of water is 2256kJ/kg. Answer the following questions.

(a) (5 pts) How much work is done by the system during the expansion process?

(b) (5 pts) How much energy is transferred as heat during the process?

(c) (10 pts) On the average, which one, a water molecule in the 100℃ liquid water or a water molecule in the 100℃ steam, has higher energy? Explain your answer using answers of the above questions 3(a) and 3(b).

4. (30 pts) Maxwell's equations, while supplemented by the Lorentz force equation $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ and the conservation of charge, describe a lot of the electromagnetic phenomena we encounter. Collectively, Maxwell's equations consist of the following four equations:

Gauss' law for electricity　　　　$\oint \vec{E} \cdot d\vec{A} = q / \varepsilon_0$

Gauss' law for magnetism　　　　$\oint \vec{B} \cdot d\vec{A} = 0$

Faraday's law　　　　　　　　$\oint \vec{E} \cdot d\vec{s} = -d\Phi_B / dt$

Ampere-Maxwell law　　　　　$\oint \vec{B} \cdot d\vec{s} = \mu_0 (\varepsilon_0 d\Phi_E / dt + i_{inc})$

Answer the following questions.

(a) (15 pts) In your opinion, why is the electric charge considered as the source of electric field?

(b) (15 pts) Is there anything that can be considered as the source of magnetic field? Explain your answer.