1-6 多選題（正確答案可能不只一個，全部選對才有分）

1. (5%) For electrostatic field, (a) the surface integral of E-field over a closed surface is $5q/\varepsilon_0$ if there are +3q and -2q charges enclosed in the surface (b) if the charge density is zero everywhere then the divergence of the E-field is unity (c) the E-field inside a perfect conductor is uniformly distributed but not zero such that there is only normal component of E-field on the conductor surface (d) the line integral of the E-field along any arbitrary opened path must be zero such that the amount of work required to move a charge in the field from one end point to another end point of the path is independent on the path selected (e) it is impossible to find a point in space as the absolute zero potential point (f) none of the above.

2. (5%) For a capacitor, (a) it is better to use a low dielectric constant material in the capacitor in order to store large amount of charge (b) in the case of electrostatics, the line integrals of the E-field along any arbitrary path that has end points terminate at each plate of a two-plate capacitor are the same even if the path extends outside the plates (c) if the polarization vector of the dielectric material inside the capacitor has none zero divergence, there will be net charge density inside the capacitor (d) air is the best dielectric material for the capacitor to store large amount of charge (e) when we say that the dielectric material is linear, we mean that the polarization vector is a linear function of the E-field (f) none of the above.

3. (5%) For lightning phenomenon (閃電), (a) in order to protect the building from lightning stroke(雷擊), it is better to have the tip of the lightning arrestor (避雷針) as sharp as possible because the sharp tip has a low induced electric field (b) it is safer if the dielectric strength of air could be as low as possible to avoid dielectric breakdown (c) the lightning is due to the massive ionization of air and corona discharge (d) the induced electric field on the surface of the lightning arrestor is in the tangential direction (e) the electrostatic potential at the tip of the arrestor is higher than that at the rest part of the arrestor (f) none of the above.

4. (5%) A d-c motor consists of a current loop placed in a single N-S pair static magnet; (a) the current should change direction twice for each turn of rotation (b) the motor would work at the highest efficiency if the current does not change direction in the loop (c) the magnetic moment of the loop will be rotating with the loop (d) the total torque acting on the loop is constant in time (e) for an ideal motor, there should be no hysteresis loss in the magnet when the motor is rotating (f) none of the above.

5. (5%) For a circular current loop in a uniform magnetic field with the loop normal parallel to the field, there will be induced emf (a) if the magnetic field is changing with time (b) if the size of the loop is changing with time in the static field (c) if the loop is moving along the direction of the static field (d) if the loop is moving perpendicular to the static field (e) none of the above.

6. (5%) It is possible to heat up a material with a time varying magnetic field, (a) the material should be a lossless dielectric (b) the material should be a conductor (c) this phenomenon is necessary for a transformer to be durable (d) this phenomenon is caused by Joule heating of the displacement current (e) the eddy current should be zero for this phenomenon to happen (f) none of the above.

7. (20%) It is possible to obtain the following phasor solutions for the electric field of a plane wave in a

   simple medium from the Helmholtz equation $\nabla^2 \vec{E} + k^2 \vec{E} = 0$, (i) $E = E_0 e^{-j\alpha x - j\beta y}$ (ii)

   $E = E_0 e^{-\alpha x - j\beta x}$, (iii) $E = E_0 e^{-\alpha x - j\beta y}$, and (iv) $E = E_0 e^{-\alpha x}$, where E_0 is the electric field amplitude,

   α, β, γ are real numbers, $j = \sqrt{-1}$ is the imaginary unit. The wave number $k = \omega\sqrt{\varepsilon\mu}$ can be a real

   or complex number, in which ω is the angular frequency of the wave, ε is the permittivity, and μ
   is the permeability. Assume $\alpha < \beta$.
   a. (5 %) Under what circumstance would you obtain a solution like (i)?
   b. (5 %) Under what circumstance would you obtain a solution like (ii)?
   c. (5 %) Under what circumstance would you obtain a solution like (iii)?
   d. (5 %) Under what circumstance would you obtain a solution like (iv)?
    * no credit will be given without explanations.

8. (15%) A time-varying, radially symmetric magnetic flux $\phi(r,t)$ drives an electron to perform circular motion at $r = a$, where a is a constant and t is the time variable.
   a. (5 %) Derive an expression for the electron momentum as a function of $\phi(r,t)$, a, and the
      electron charge e. The electron momentum is defined through the force experienced by the

      electron $F = \dfrac{dp}{dt}$, where $p = mv$, m is the electron mass and v is the electron velocity.

   b. (5%) The electron circular motion at $r = a$ is only possible when the centrifugal force $\dfrac{mv^2}{a}$ is

      balanced by the inward forced provided by the magnetic field $B(r = a,t)$. Find the relationship
      between $B(a,t)$ and $\phi(r = a,t)$.

   c. (5%) As shown in the following plot, the time-varying, radially symmetric magnetic field is given
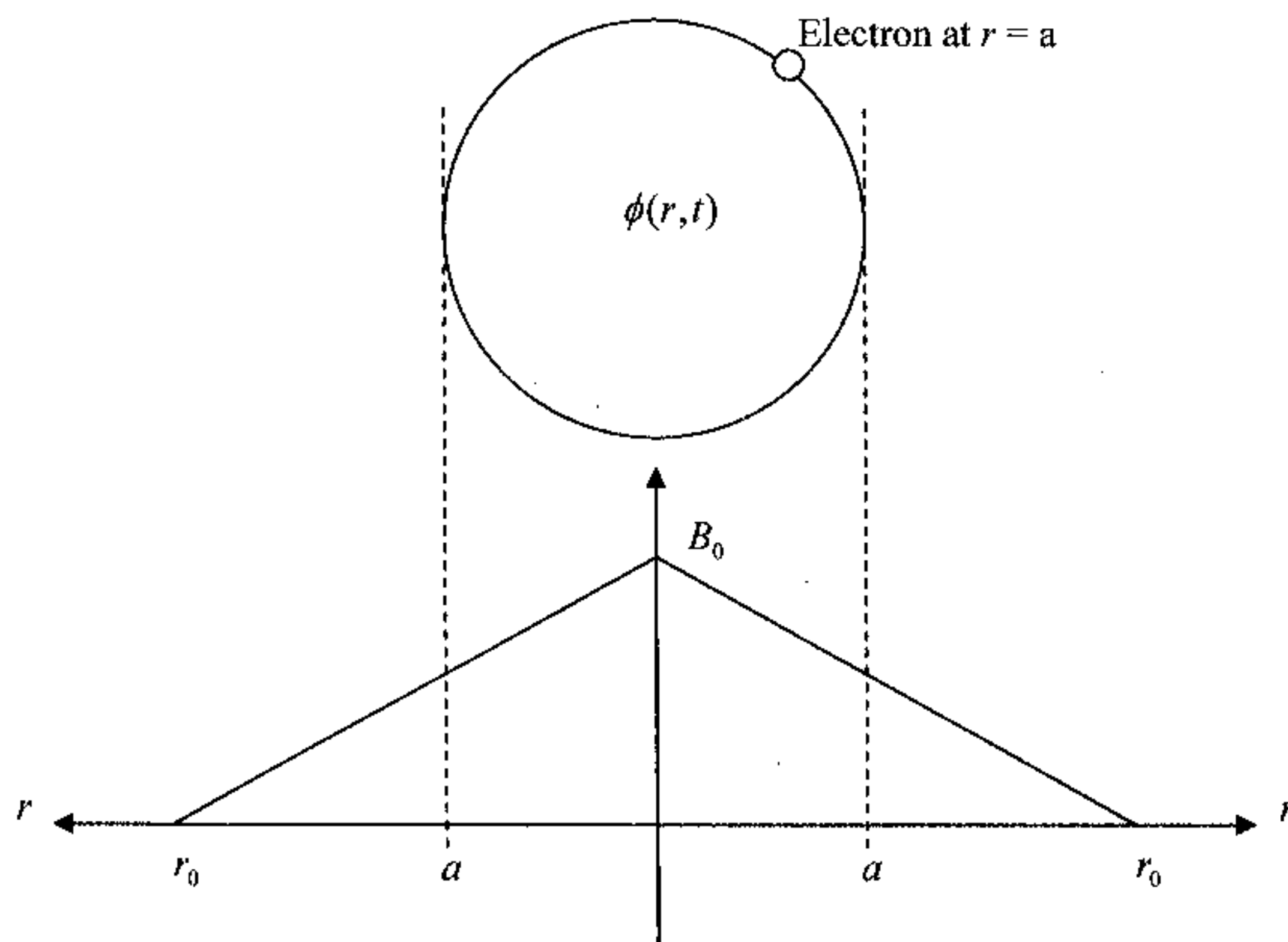   by

      $B(r,t) = B_0(1 - \dfrac{r}{r_0}) \times f(t)$,   for $r < r_0$,

      $B(r,t) = 0$,   for $r \geq r_0$,

where B_0 is the peak magnetic field at the origin and $f(t)$ is a time-varying function. The direction of the magnetic field is normal to the plane of the circle. Find the electron location, a, as a function of r_0.

9. (15%) The phasor representation of the electric field of a z-propagating, x-polarized electromagnetic wave $\vec{E}(t,z) = \hat{x}|E_0|\cos(\omega t - kz - \phi)$ is given by $\vec{E} = \hat{x}E_0 e^{-jkz}$, where $\hat{x}$ is the unit vector in the x direction, ω is the angular frequency of the wave, k is the wave number, $E_0 = |E_0|e^{-\phi}$ is the complex amplitude of the wave with phase ϕ, and $j = \sqrt{-1}$ is the imaginary unit. The electric-field phasors of two counter-propagating electromagnetic waves are therefore given by

$\vec{E}_1 = E_0(\hat{x} + j\hat{y})e^{-jkz}$ and $\vec{E}_2 = E_0(\hat{x} + j\hat{y})e^{jkz}$.

a. (5%) Plot the electric field vector in the x-y plane for $\vec{E}_2 = E_0(\hat{x} + j\hat{y})e^{jkz}$ when an observer views the wave toward +z direction. Indicate in the plot the direction of rotation of the electric field
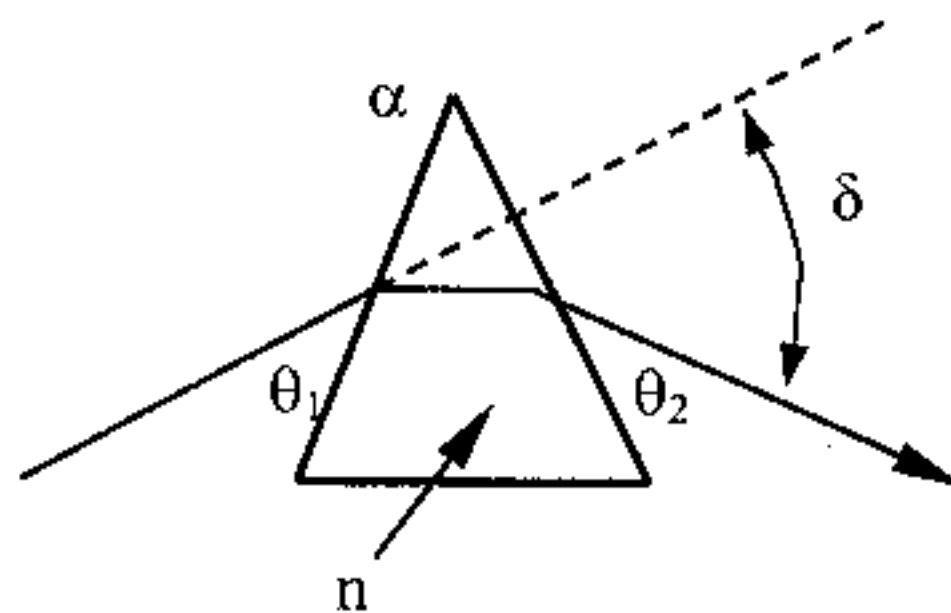
vector.

b. (10%) What is the time-average Poynting vector of $\vec{E}_1 + \vec{E}_2$?

10. (10%)An optical ray passes through a prism as shown. Determine the angle θ_2 and the deviation angle δ as function of the refractive index n and the apex angle α when $\theta_1 = \theta_2$.

11. (10%) Explain the following terms.

 甲、Aperture stop, field stop, entrance pupil and exit pupil. (6%)

 乙、Frustrated total internal reflection. (4%)