

1. In a circular region of radius $R = 6.00$ cm, there is a uniform electric field, whose direction is normal to that circular surface. The magnitude of the electric field increases with time as $E = (10^3/\pi)t$ V/(meter sec) , where t is time. The electric field is zero at radial distances larger than R . What are the magnitudes of the induced magnetic field at radial distances 4.00 cm and 8.00 cm, respectively? [10%]
2. Silicon's density is 2.33 g/cm³ and atomic weight 28.1 u. The electron number density in the conduction band of pure silicon at room temperature is about 5×10^{15} m⁻³. Suppose one of every 10^7 silicon atoms is replaced by a phosphorus atom.
 - (a) Is this doped semiconductor n-type or p-type? What is the majority carrier? [2%]
 - (b) What charge-carrier number density will the phosphorus add? [4%]
 - (c) What is the ratio of the charge-carrier (electrons in the conduction band and holes in the valence band) number density in this doped silicon to that in pure silicon? [4%]
3. Frame S' moves at speed $v = 0.60c$ along the $+x$ axis in frame S .
 - (a) A rod is at rest in S frame and is measured to be 2.0 m long in frame S' . What is its length as measured in frame S ? [5%]
 - (b) The heart beat of a certain person at rest in frame S is 72 times per second as measured in frame S . How many times per second will that be measured in frame S' ? [5%]
 - (c) A particle travels at $u' = 0.40c$ in frame S' and at 60° to the $+x'$ axis of frame S' . What are the x- and y-components of its speed (u_x and u_y) as measured in frame S ? [10%]
4. The H_α line emitted from a galaxy is measured at a red-shifted wavelength 660.28 nm. Assuming the galaxy is moving only in the direction of the line of sight, what is its speed? [10%]
5. For an object moving at a speed of $0.6c$, what would be the angle between its motion and the line of sight if there is no red- or blue-shift observed? [10%]
6. What are the speed and linear momentum (in SI units) of an electron with a total energy of 3.0 GeV? [10%]
7. A certain material with a work function ϕ of 1.2 eV is bombarded by a beam of red light (650 nm wavelength) at an intensity level of 10^4 photons per second. What is the stopping potential for the photo-electrons? [10%]

8. When a photon of energy 1.0 MeV is scattered by an electron at rest, what is the maximum kinetic energy that could be transferred to the electron? [10%]
9. The mass of a proton is 1.007825 u, of a neutron 1.008665 u, and of the europium isotope ${}_{63}^{152}\text{Eu}$ 151.921742 u. What is the binding energy per nucleon of ${}_{63}^{152}\text{Eu}$ in units of MeV? [5%]
10. A black, totally absorbing cardboard of area 1.0 cm^2 is illuminated in its surface-normal direction by a light of intensity 24 W/m^2 . What radiation pressure is produced by the light on the cardboard? [5%]