Phys106, II-Semester 2018/19, Assignment 4

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Hint: For all these questions (and later ones) you may use the math software `mathematica`*, available from CC. The little overhead in familiarising yourself with it now, will pay off manyfold later, regardless of your major.*

1. (a) Since photons carry momentum, when they reflect off a mirror they exert a force on that mirror, called radiation pressure. From your knowledge of the photon momentum, infer a simple equation how radiation pressure depends on light intensity. Use momentum conservation laws for that, see Fig. 1.

   Hint: You may also need the following relations: $F = dp/dt$ (Force is change of momentum per unit time), $P = F/A$ (Pressure is force per unit Area). Recall assignment 3 where you had already looked at the relation between light intensity and photons contained in it.

   (b) Solar radiation has an intensity of about $I_{sol} = 1400\ W/m^2$ at the earth orbit.

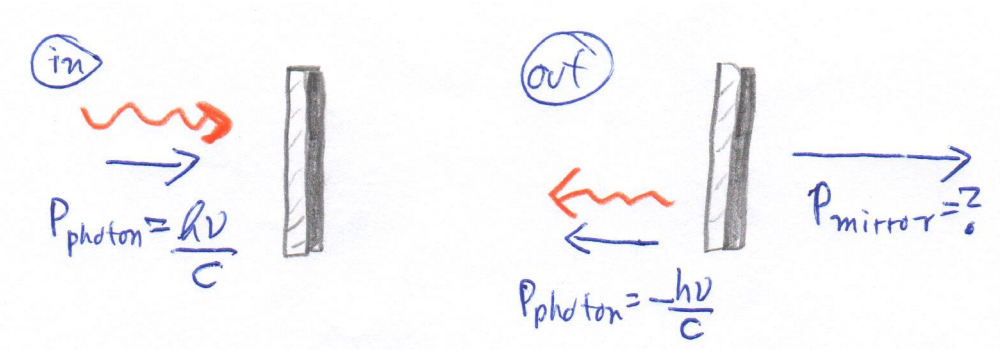

Figure 1: Momentum conservation diagram when a photon reflects off a mirror.

   If you build a square solar sail (very thin mirror type sheet) of area 1 km^2 and tie it to a space-probe of mass $m = 1$ kg, what acceleration does the space-probe experience? Is this a great way to build spaceships?

2. Show that electron positron pair production cannot occur in free space without looking at the lecture calculation. Only start from the diagram on page three of section 2.2.7), then apply energy and momentum conservation with the relativistic formulae given in section 2.2.5).

3. Calculate the Compton wavelength of (i) a muon neutrino (let us assume a rest mass 0.05 eV/c^2. The true value is still not known) (ii) an electron, (iii) a proton (iv) a Na atom ? Which of these will show the nicest signal in X-Ray scattering? What is the maximum wavelength shift in scattering from protons?