Flying on Sunshine Questions

1 The Sun emits light with a peak wavelength of around 500nm.
   a) Calculate the frequency.
   b) Calculate the photon energy in Joules.
   c) Calculate the photon energy in eV.

2 A photovoltaic cell can produce an e.m.f. of 0.5V.
   a) What energy is supplied to each electron by each photon in eV?
   b) Calculate the energy supplied to each electron in Joules.
   c) Calculate the maximum wavelength of light that the photovoltaic cell can make use of.
   d) Explain why light with a longer wavelength will produce no e.m.f from the cell.

3 Carbon fibre, used in Solar Impulse's wings is low density, stiff and strong.
   Explain the meaning of the terms **and** suggest why each property is desirable.
   Include the terms Young modulus and yield stress in your explanations.

   a) low density b) stiff c) strong

4 Use the **Solar Impulse 2 Data** and data in the text to calculate:
   a) The length of the sides of the solar cells (assuming they are square).
   b) The energy that can be stored in the batteries.
   c) The mean width of the wings.
   d) The gravitational potential energy lost during the 4 hour glide.
   e) The power at which GPE is lost during the glide.
   f) Make a sensible estimate as to the power required to keep the plane aloft.
   g) Calculate the solar energy input required to supply this power.
   h) Calculate an estimate of the solar radiation flux in Wm^{-2}.
   i) Calculate the time required to fully charge the storage batteries.

5 Juno uses a gravitational slingshot to increase its velocity.
   a) Calculate the kinetic energy gained by Juno.
   b) Explain the source of this energy.
   c) Calculate the change in momentum of Juno.
   d) Explain how the total momentum is conserved.
   e) The slingshot took around 9 hours. Calculate the mean gravitational force on Juno.

6 Light intensity follows in inverse square law.
   a) Calculate what fraction of the Earth's solar flux that Juno receives.
   b) Calculate power supplied by the solar cells assuming an efficiency of 35%

7 Juno will orbit Jupiter, which has a mass of 1.9×10^{27} kg, once every 14 Earth days.
   a) Calculate the orbital period in seconds.
   b) Use the equations for centripetal acceleration and gravitational force and the data above to **show that** the average radius of Juno's orbit around Jupiter is about 1.7 million kilometres.
   c) Calculate the velocity of Juno in its orbit around Jupiter.
   d) Jupiter has a diameter of 143000 km. Calculate the speed that Juno will enter the top of Jupiter's atmosphere.