Assignment 2: Modern Physics
Due Date: 13th February 2018, 4 pm

Note: This is a collaborative assignment. Submit in upto groups of four. Write all four names and roll numbers clearly on the first sheet.

1. At what rate does the Sun emit photons? For simplicity, assume that the Suns's entire emission at the rate of 3.9×10^{26} W is at the single wavelength of 550 nm.

2. The wave function of a particle confined to move in a one-dimensional box of length L is,

$$\psi(x) = A \sin\left(\frac{2\pi x}{L}\right).$$

   (a) Use normalization condition to find the value of A.

   (b) Calculate the probability of finding the electron between $x = 0$ to $x = L/4$.

3. Consider a particle whose wave function is given by the following expression,

$$\psi(x) = Ae^{-ax^2}.$$

   (a) What is the value of A if this wave function is normalized?

   (b) What is the expectation value of x for this particle? What does the "expectation value" mean?

4. The uncertainty in the position of a cricket ball of mass 0.145 kg is 1 μm. What is the minimum uncertainty in its speed?

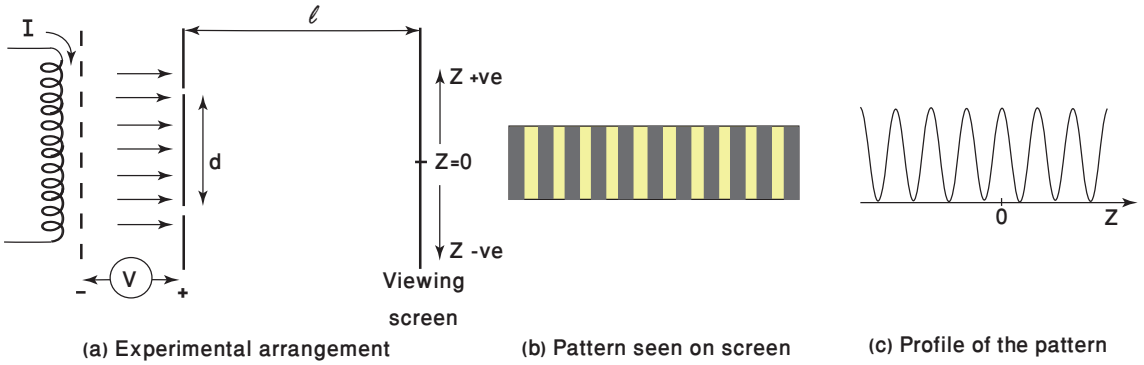
5. A mosquito of mass 0.15 mg is found to be flying at a speed of 50 cm/s with an uncertainty of 0.5 mm/s.

   (a) How precisely may its position be known?

   (b) Does this inherent uncertainty present any hindrance to the application of classical mechanics?

6. The position of a neutron in nucleus is known within an uncertainty of $\sim 5 \times 10^{-15}$ m. At what speeds might we expect to find it moving?

7. A beam of electrons is accelerated through a potential difference V. The beam is then incident on a screen with two slits and a viewing screen is placed far away. An interference pattern is viewed on the screen as shown.



(a) Experimental arrangement (b) Pattern seen on screen (c) Profile of the pattern

(a) Why is an interference pattern observed?

(b) Suppose the experiment is repeated with an accelerating potential of 0.5 V instead of V. How will the interference pattern change? Sketch the pattern clearly as well as the profile and compare with the original observations shown in Fig.(a) and (b).

(c) If V is reduced to 0.5 V, what is the effect on:

(i) K.E. of each electron reaching the slits?

(ii) Momentum of each electron reaching the slits.

(d) If the acceleration potential is still V (with the direction of V reversed of course), how would the interference profile change if one were to use protons instead of electrons? Draw sketches where possible.