Workshop Tutorials for Physics

QR1: **Photons**

A. Qualitative Questions:

1. Light is commonly described in terms of brightness and colour. Copy and complete the following table by filling in the quantities in the wave and particle models of light which relate to colour and brightness.

	Wave Model	Particle Model
Brightness		
Colour		

2. Electrons are ejected from a surface when light of a certain frequency is incident upon the surface. What would happen to the maximum kinetic energy of the individual ejected electrons if
a. the intensity of illumination was doubled?
b. the length of time of exposure to light was doubled?
c. the frequency of the light was doubled?
d. the material of the surface was changed?
Explain your answers.

B. Activity Questions:

1. Photoelectric effect
Draw a series of sketches which show how you can observe the photoelectric effect using this apparatus.
Why do you think the 'Photoelectric Effect" is one of the first topics studied in quantum mechanics?
In the photoelectric effect, why does the existence of a cutoff frequency speak in favour of the photon theory and against the wave theory?

2. Wave and particle nature of light 1- interference pattern
Observe the interference pattern produced by the laser light passing through the slits.
Does this experiment show the wave nature or particle nature of light? Explain your answer.

3. Wave and particle nature of light 2- emission spectra
Use the spectroscope to examine the spectral lines of the hydrogen lamp.
Which model of light does this experiment support? Explain your answer.

C. Quantitative Questions:

1. The photoelectric effect was extremely important in the development of quantum physics. It was Einstein's explanation of the photoelectric effect that won him his Nobel prize, and *not* his theory of relativity which led to the famous "$E = mc^2$" equation.

a. Write down the "photoelectric equation" and explain how this is consistent with the principle of conservation of energy.

b. Do you expect all the ejected electrons to have the same kinetic energy? Explain your answer.

Two units for energy are commonly used in physics, the joule (J) and the electron volt (eV). This problem could be solved using either J or eV.

Ultraviolet light illuminates an aluminium surface. Using the data below determine :

c. the kinetic energy of the fastest emitted photoelectrons,

d. the kinetic energy of the slowest emitted photoelectrons,

e. the stopping potential,

f. the cut-off wavelength for aluminium.

Data: $h = 6.63 \times 10^{-34}$ J.s
$c = 3.00 \times 10^{8}$ m.s
$1\ \text{eV} = 1.60 \times 10^{-19}$ J
$\Phi_{Al} = 4.20$ eV
$\rho_{Al} = 2.75 \times 10^{-8}\ \Omega$.m
$\lambda_{UV} = 200$ nm

2. A caesium surface is illuminated with 600 nm light from a laser.

a. Calculate the energy of the photons emitted from this laser.

b. Given that the laser has a power of 2.00 mW, calculate the number of photons emitted per second.

Photosensitive surfaces are not always very efficient. Suppose the fractional efficiency of a Cs surface is 1.00×10^{-16} (one in every 1.00×10^{16} photons ejects an electron).

c. How many electrons are released per second?

d. Determine the current if every photoelectron takes place in charge flow.

e. Explain the difference, if any, between an electron and a photoelectron and a current and a photocurrent.