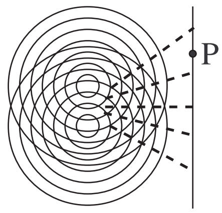
Part I

1. Two in-phase sources produce circular waves of wavelength λ and the interference pattern is shown to the right, with dotted lines indicating where constructive interference occurs.
The difference in the path length from each of the sources to point P is



(a) $\lambda/2$ (b) λ (c) $3\lambda/2$ (d) $5\lambda/2$

Answer (c): The middle dotted line is constructive interference where the difference in path length is zero. The next line up which is just below P shows constructive interference with difference in path length of λ the 2nd line up which is above P shows constructive interference with difference in path length of 2λ. So P indicates a region with destructive interference and the difference in path length must be $3\lambda/2$.

2. A diffraction grating is illuminated with yellow light. The pattern seen on a screen behind the grating consists of three yellow spots, one at zero degrees (straight through) and one each at $\pm 45^o$. You now add red light of equal intensity, coming in the same direction as the yellow light.The new pattern consists of

   (a) red spots at 0^o and $\pm 45^o$
   (b) orange spots at 0^o and$\pm 45^o$
   (c) an orange spot at 0^o, yellow spots at $\pm 45^o$, and red spots slightly farther out.
   (d) an orange spot at 0^o, yellow spots at $\pm 45^o$, and red spots slightly closer in.

   Answer (c): In diffraction there is a spot at 0^o for all wavelengths so the red and yellow combine there to make orange. Since red light has a longer wavelength than yellow light it will be diffracted at a slightly greater angle than yellow.

3. An interference pattern is formed on a screen by shining a planar wave on a double- slit arrangement If we cover one slit with a glass plate (right), the phases of the two emerging waves will be different because the wavelength is shorter in glass than in air. If the phase difference is 180^o, how is the interference pattern changed?

   (a) The pattern vanishes.
   (b) The bright spots lie closer together.
   (c) The bright spots are farther apart.
   (d) Bright and dark spots are interchanged.

   Answer (d): Since one slit shifts is shifted 180^o out of phase with the other slit then where previously there was constructive interference there will be destructive interference and vice versa.

4. Blue light of wavelength λ passes through a a double slit with separation d and forms an interference pattern on a screen. If the blue light is replaced by red light of wavelength 2λ, the original interference pattern is reproduced if the slit separation is changed to

   (a) $2d$

   (b) $d/2$

   (c) No change is necessary.

   (d) There is no separation that can be used to reproduce the original pattern.

   Answer (a): Doubling the wavelength would tend to double the fringe separation. Doubling the slit separation would tend to halve the fringe separation. Combining both these changes would reproduce the original pattern – but in red rather than in blue.

Part II

1. Monochromatic light illuminates a narrow slit which is 4.0 m from a screen. Two very narrow parallel slits 0.5 mm apart are placed halfway between the single slit and the screen so that interference fringes are obtained.

   If the spacing of five fringes is 10 mm calculate the wavelength of the light.

   $y = \frac{n\lambda L}{d} \Rightarrow \lambda = \frac{yd}{nL}$ Note: $n = 4$ not 5 since the central peak is $n = 0$

   so $\lambda = \frac{(10 \times 10^{-3})(0.5 \times 10^{-3})}{(4)(2.0)} = 625$ nm

   What will be the effect on the fringes of

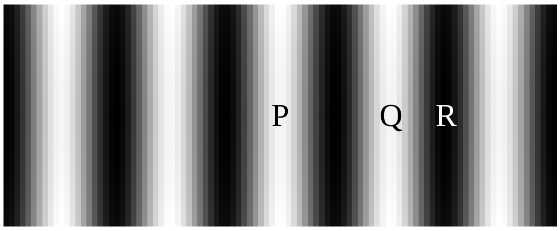
   (a) halving the distance between the double slit and the screen;
   The fringe separation is halved.

   (b) halving the slit separation;
   The fringe separation is doubled.

   (c) covering one of the double slits;
   The interference pattern is lost (There may be an observable diffraction pattern.)

   (d) using white light.
   The fringes separate into component colours with read spreading further and blue less – The central fringe will remain white.

2. Red light, with wave length λ is incident on two slits. The light passing through the slits forms a fringe pattern on a screen which is a distance 2.2 m from the slits. The fringe pattern is shown on the right. The point P is at the center of the pattern directly opposite the slits. P and Q are maximum intensity and R is a minimum intensity fringe.



(a) Explain why there are dark and light fringes.
There are light fringes because light from the two slits interferes constructively there and there are dark fringes because light from the fringes interferes destructively there.

(b) What is the difference in path length from each of the two slits to the point P? The point Q? The point R? Express your answer in terms of the wavelength λ.
For point P the difference in path length is zero. For Q the difference in path length is one wave length, since it is the first maximum. Since R is the second minimum, the difference in path length is one and a half wavelengths or $3\lambda/2$.

(c) If the distance between P and R is 1.6 mm, find the slit separation in terms of λ.
One fringe separation is the distance between P and Q. This is 2/3 of the distance between P and R ie $1.6 \times 2/3 = 1.1$ mm. Now the slit separation is $d = x\lambda/\Delta y = 2.2\lambda/(1.1 \times 10^{-3}) = 2000\lambda$.

(d) Suppose the width of the slits on the right were decreased without changing the distance between the centers. Would the brightness of at Q increase,decrease or stay the same? What about R? Explain?
At point Q the intensity would decrease since less light would reach there to constructively interfere with light from the other slit. At point R the intensity would increase. There is not enough light from the right slit to completely destructively interfere with the light from the left slit.