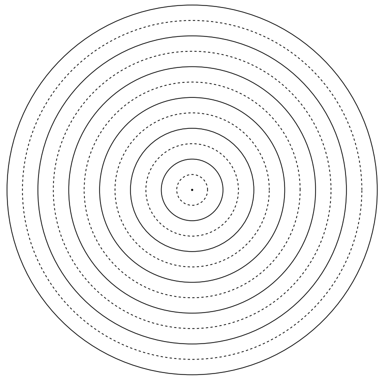
Part I

1. The diagram on the right represents a snapshot of the wavefronts of a periodic circular wave in a portion of a ripple tank. The dark circles represent crests and the dashed circles troughs.



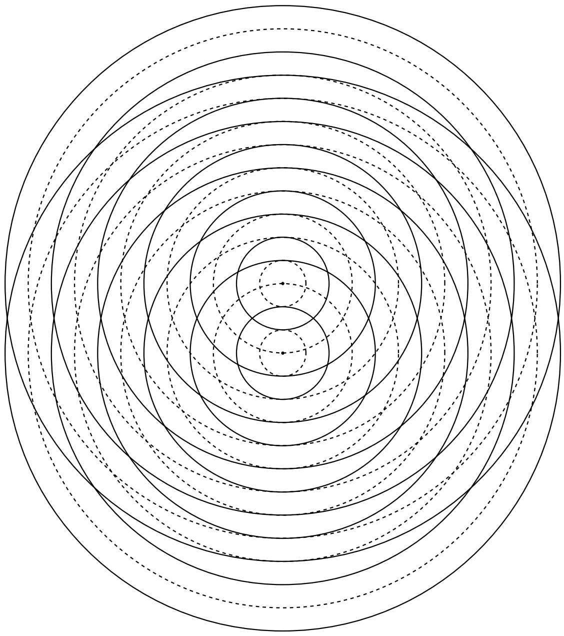
   How would the diagram differ after

   (a) one half a period?
   The dotted and dashed lines would be switched.

   (b) one whole period?
   It would look similar, but there would be two more larger circles.

   (c) a quarter period?
   Each line would move halfway to the next line.

2. The diagram shows a snapshot of the wave fronts in water due to two small sources.



   (a) How do the frequencies compare?
   They are the same.

   (b) How far apart are the two sources? Express your answer in terms of wavelength.
   They are one and half wave lengths apart.

   (c) Mark all points where a crest meets a crest with one color. What happens to the water at these points?
   They oscillate with maximum amplitude.

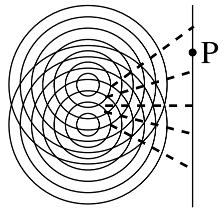
   (d) Mark all points where a trough meets a crest with another color. What happens to the water at these points?
   They are at equilibrium and stay there.

   (e) Mark all points where a trough meets a trough with a third color. What happens to the water at these points?
   They oscillate with maximum amplitude.

3. On the diagram above you should find points arranged in lines. Lines along which troughs meet crests are called *nodal lines*. Pick a few points on each nodal line and determine the difference in the distance from that point to each source, in units of wavelength? What do you notice? Repeat this analysis for the lines along which crests meet crests and troughs meet troughs. These are called lines of *maximum constructive interference*.
   Along nodal lines the difference in distance is an odd multiple of half a wavelength. Along lines of maximum constructive interference the difference in distance is a multiple of a wavelength.

Part II

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.

5. Suppose we cover each slit in Young's experiment with a polarizer such that the polarization transmitted by each slit is perpendicular to that transmitted through the other. On a screen behind the slits, we see:

   (a) the usual fringe pattern.

   (b) the usual fringes shifted over such that the maxima occur where the minima used to be.

   (c) nothing at all.

   (d) a fairly uniformly illuminated elongated spot.

   Answer (d): Since the light passing through one slit polarized perpendicular to the light passing through the other slit they cannot interfere (add or subtract). You would therefore expect to see a wide band of light without interference fringes.

Part III

1. In a Young's double slit experiment using yellow light of wavelength 550 nm the fringe separation is 0.275 mm.

   (a) Find the slit separation if the fringes are 2.0 m from the slit.
   If d is the slit separation and Δy is the fringe separation then $\Delta y = x\lambda/d \;\Rightarrow\; d = x\lambda/\Delta y = 2.0(550 \times 10^{-9})/(0.275 \times 10^{-}3) = 0.004$ m $= 4$ mm

   The yellow lamp is replaced with a purple one whose light is made of two colours, red light of 700 nm and violet light of 400 nm.

   (b) Find the distance between the violet fringes
   $\Delta y = x\lambda/d \;\Rightarrow\; \Delta y = 2.0(400 \times 10^{-9})/0.004 = 2.0 \times 10^{-4}$ m $= 0.20$ mm

   (c) Find the distance between the red fringes
   $\Delta y = x\lambda/d \;\Rightarrow\; \Delta y = 2.0(700 \times 10^{-9})/0.004 = 3.5 \times 10^{-4}$ m $= 0.35$ mm