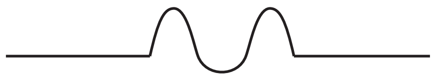
Part I

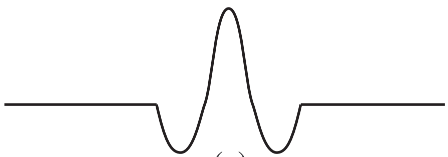
1. Two wave pulses of symmetrical shape approach one another on a string, as shown in the diagram.

Which one of the following diagrams could not be observed at a later time?

(a)



(b)



(c)

(d)

Answer (b). The displacement in the middle of the combined pulse is half rather than double the two individual displacements.

2. In a standing wave

   (a) the nodes are positions of maximum amplitude.

   (b) all points of the wave vibrate with the same amplitude.

   (c) the distance between successive nodes is one wavelength.

   (d) all the points between every other pair of nodes vibrate in phase.

   Answer (d).

3. Two sinusoidal waves travel in the same medium but one with twice the wavelength of the other. Which of the following statements is true? The wave with the longer wavelength has

   (a) higher speed.

   (b) lower speed.

   (c) higher frequency.

   (d) lower frequency.

   Answer (d). The medium remains the same so the speed is unchanged and hence the frequency must decrease

4. Two air columns are identical except that one is open at both ends while the other is closed at one end. When they oscillate at their fundamental frequency, which one of the following quantities is the same for the sound wave associated with each column.

   (a) Wavelength
   (b) Frequency
   (c) Wave speed
   (d) Number of antinodes.

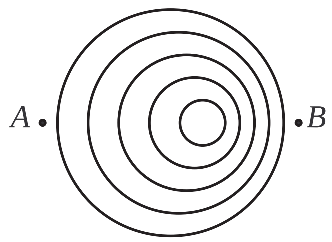
   Answer (c). Wave speed depends on the medium which has not changed. When both ends are open the wavelength of the fundamental mode is twice the length of the pipe. When one end is open the wavelength is four times the length of the pipe.

5. A string which is fixed at both ends vibrates at its fundamental frequency. The tension of the string is now increased and the string is again made to vibrate at is fundamental frequency. Which one of the following statements about the change in the properties of the wave is correct

   (a) The wave speed increases and the wavelength increases.
   (b) The wave speed increases and the frequency increases.
   (c) The wave speed decreases and the wavelength decreases.
   (d) The wave speed decreases and the frequency decreases.

   Answer (b). Tension causes the wave speed to increase and hence the frequency.

6. Two observers A and B listen to sound from a moving source. The diagram on the right shows the wave fronts of crest of a wave. Which of the following statements is true



   (a) The wavefronts move faster at A than at B
   (b) The wavefronts move faster at B than at A
   (c) The frequency of the sound is highest at A
   (d) The frequency of the sound is highest at B

   Answer (d). The wave is moving in the same medium, so the speed is the same

7. A rescue vehicle rapidly approaches a casualty who has had a mishap at the base of a cliff. The casualty observes that the frequency of the siren has shifted higher due to the Doppler effect. The sound of the siren reflects off the cliff and is heard as an echo by the rescuers. The frequency of the echo that they hear is

   (a) is the same as the sound the casualty hears.
   (b) is higher than the sound the casualty hears.
   (c) is lower than the sound the casualty hears hears, but higher than the sound of the siren.
   (d) is identical to the sound of the siren.

   Answer (b). The sound that reflects off the cliff is Doppler shifted up in frequency since the source is approaching the cliff. The rescue vehicle is approaching this reflected wave so again the sound will be shifted up in frequency.

Part II

1. Two radio transmitters $T1$ and $T2$ emit electromagnetic waves at a frequency of 1.44 MHz. A car is driving along the line joining them at 50 km/hr. The driver is tuned in to this station and notices that the he loses his reception for a brief moment and that this occurs at regular intervals on his journey.

   (a) Find the distance between two gaps in reception.
   The waves from the two towers interfere and set up a standing wave pattern. The distance between two nodes is half a wavelength. $\lambda = c/f$ where in this case c is the speed of light so $\lambda = 3 \times 10^8/1.44 \times 10^6 = 208$ m. So the distance between nodes is 104 m.

   (b) How long does it takes to travel between them?
   Time $t = d/v$ where v is the speed of the car. $v = 50$ km/hr $= 13.9 m/s$ so $t = 104/13.9 = 7.5$ seconds

2. A guitar string of length 80 cm oscillates in its fundamental mode with a frequency of 440 Hz.

   (a) Draw pictures showing the shape of the modes of vibration for the first three harmonics and indicate the value of their wavelengths.
   $\lambda_1 = 2L = 1.6$ m, $\lambda_2 = L = 0.8$ m, and $\lambda_3 = 2L/3 = 0.533$ m.

   (b) What would be the speed of a wave traveling down this string.
   $v = \lambda f = 1.6(440) = 704$ hz

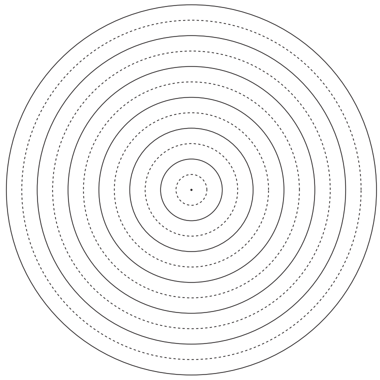
   (c) What would be the frequency of the string if it were pressed down at the 60 cm mark. If A is 440 hz, what note is this?
   $f = v/\lambda$, and the wave length is $2L = 1.2$, so $f = 704/1.2 = 587$ hz. This is a D, because D is the 5th note on the scale and $440(2^{5/12}) = 587$.

   (d) An identical 80 cm string, with at a different tension vibrates, at 444 Hz

      (i) Is the tension in the new string less or more?
      Speed increases with tension so frequency does also.

      (ii) If both strings vibrate together beats are heard. What is the frequency of the beats?
      The beat frequency is the difference in the two frequencies, which is 4 hz.

3. 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.



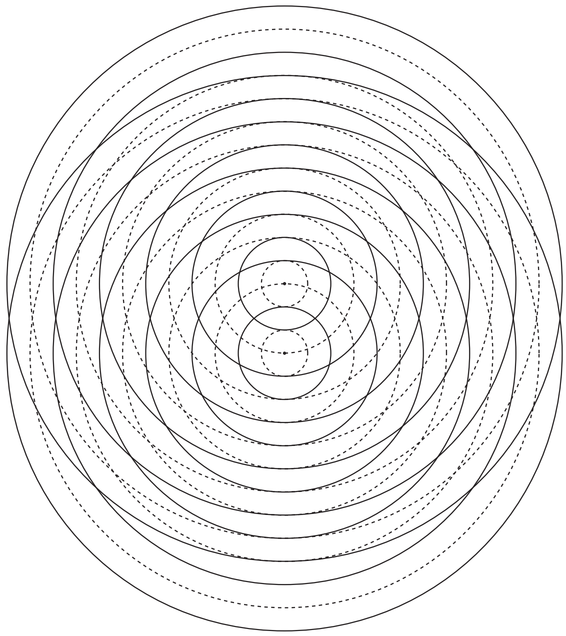
Draw how would the diagram differ after

(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.

4. 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 wavelengths 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.

5. 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.