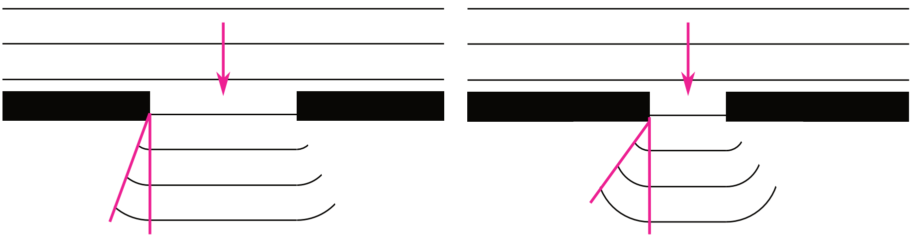
44 Diffraction ♡

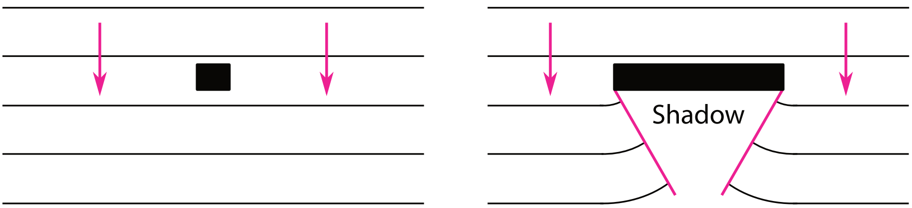
When waves encounter an obstacle or aperture (a gap), they spread out.

For gaps, the amount the waves spread out depends on the wavelength divided by the width of the aperture. In the two images below, waves are travelling from the top of the image to the bottom. The wavelength is the same in both images (the distance between the waves fronts is the same), but the width of the gap is different. Notice that the diffraction angle, marked with the coloured lines, is greater for the narrower gap.



When waves are incident on an obstacle that is smaller than the wavelength of the wave, the waves diffract around the obstacle so very little shadow can be seen.

When waves are incident on an obstacle that is larger than the wavelength of the wave, the waves diffract around the edges of the obstacle but some of the wave energy reflects back from the obstacle and there is a shadow behind the obstacle.



44.1 In the following table, label whether diffraction can be seen (Y) or not (N).

		Aperture Size		
		10.0 m	10.0 cm	0.01 mm
Wavelength	10.0 m	-	(a)	(b)
	10.0 cm	(c)	-	(d)
	0.01 mm	(e)	(f)	-

44.2 In the following table, label whether there is an obvious shadow behind the obstacle (Y) or not (N).

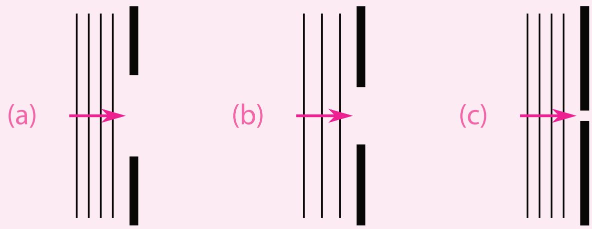
		Obstacle Size		
		5.0 m	25.0 cm	1.0 cm
Wavelength	5.0 m	-	(a)	(b)
	25.0 cm	(c)	-	(d)
	1.0 cm	(e)	(f)	-

44.3 Put these cases in order of size of diffraction angle, from largest diffraction angle to smallest, for a wave passing through an aperture. *[Hint: the larger the wavelength divided by the aperture width, the greater the diffraction angle.]*

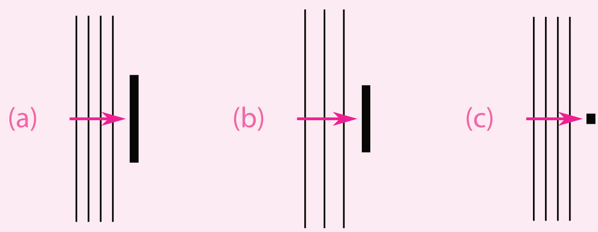
Case	Wavelength	Aperture Width
1	550 nm	0.010 0 mm
2	700 nm	0.100 mm
3	1 400 nm	100 μm
4	5.00 cm	10.0 cm
5	15.0 cm	1 000 μm

44.4 A young astronomer has a telescope with a 6.0 cm diameter lens, and uses it to take pictures using visible light (wavelength = 500 nm). If a professional astronomer wanted images just as precise using 30 cm radio waves, what diameter of dish would be needed? (The main factor causing blurring in a good telescope is diffraction.) *[Hint: use ratio and proportions.]*

44.5 Copy and complete the following diagrams by drawing the position of the water wave fronts after they have been diffracted by passing through the gaps in the barriers.



44.6 Copy and complete the following diagrams by drawing the position of the water wave fronts after they have been diffracted by passing the obstacles.



44.7 A person with perfect eyesight can only read a message written using 1.0 mm pixels if it is closer than 14 m (with a pupil diameter of 7.0 mm) because diffraction caused by the pupil blurs light from one pixel into another at greater distances. How far away could they read the same message if they used binoculars with 25 mm diameter lens? *[Hint: use ratios or proportions.]*

44.8 For satellite communications, radio and microwave transmission dishes need to be wide enough to prevent excess diffraction. Rank the following situations with the most parallel beam first.

(a) 3.0 cm microwave from a 21 cm radius dish.

(b) 15 cm radar from a 3.0 m radius dish.

(c) 500 nm light from a 8.0 μm blood cell.