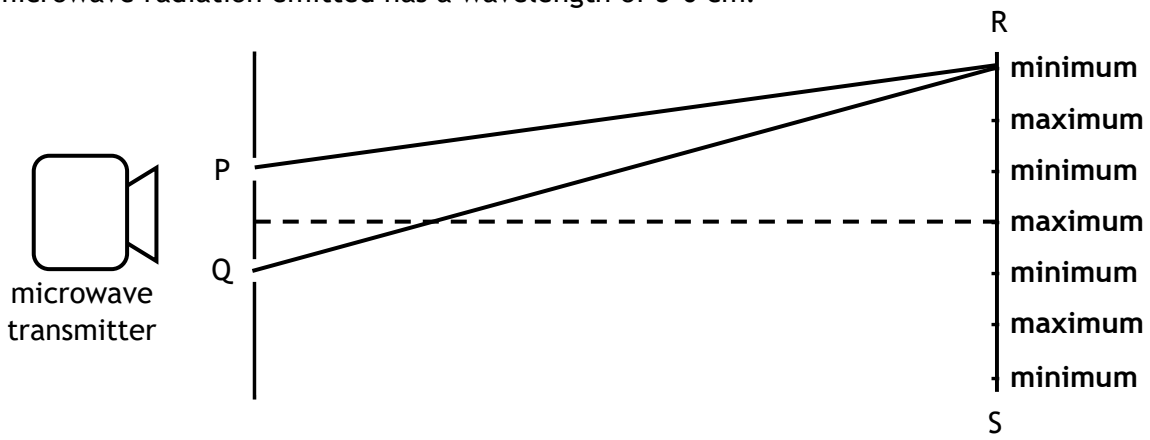
**Homework 5: Interference and Diffraction**

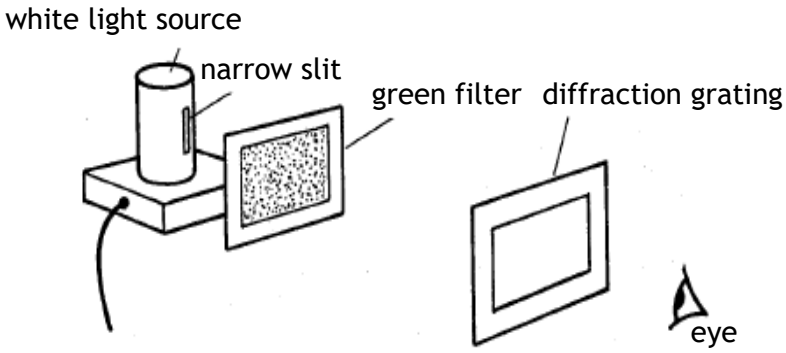
1. A microwave transmitter is directed at a metal plate which has two slits, P and Q, in it as shown. The microwave radiation emitted has a wavelength of 3·0 cm.




A microwave receiver is moved between R and S and a series of maxima and minima are detected, as shown.
Calculate the path difference between PR and QR.

A 1·5 cm
B 3·0 cm
C 4·5 cm
D 6·0 cm
E 9·0cm

2. A green filter is placed in front of a source of white light. The filtered light is viewed, as shown, through a diffraction grating with 100 lines per millimetre. A pattern of bright and dark bands are observed.

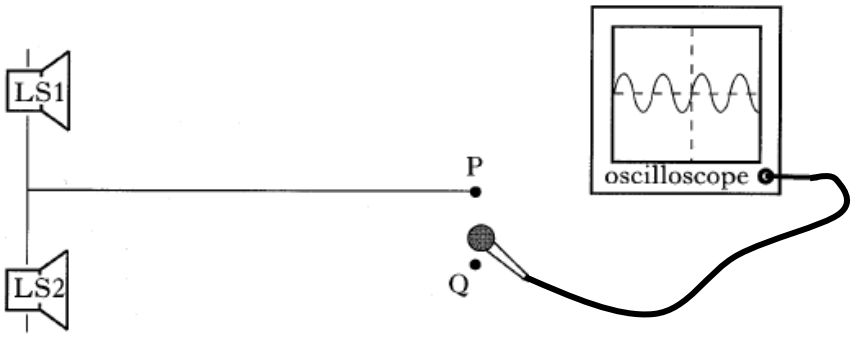



Identify which of the following changes would **decrease** the spacing between the bright bands.

I Use of a blue filter instead of the green filter.
II Use of a grating of 50 lines per millimetre instead of 100 lines per millimetre.
III Use of a brighter lamp.

A I only
B II only
C I and II only
D I and III only
E II and III only

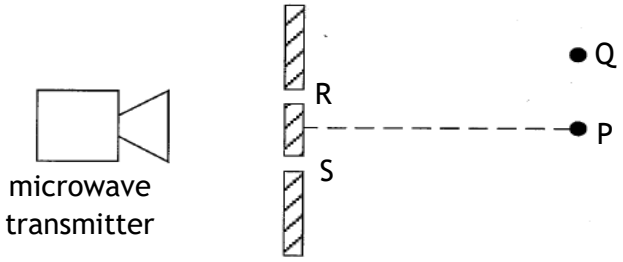
3. Two loudspeakers, LS1 and LS2, connected to the same output of a signal generator, provide coherent sources of sound waves. A microphone, connected to an oscilloscope, is used to detect the sound.
Position P is the same distance from LS1 as it is from LS2. Position Q is **one wavelength** of sound wave further from LS1 than it is LS2.




Identify which of the following statements best describes what happens to the oscilloscope trace as the microphone is slowly moved from position P to position Q.

A Constant amplitude of trace when moved form P to Q
B Minimum amplitude at P increasing to maximum amplitude at Q
C Maximum amplitude at P decreasing to minimum amplitude at Q
D Minimum amplitude at P, going through a maximum and then back to a minimum amplitude at Q
E Maximum amplitude at P, going through a minimum and then back to a maximum amplitude at Q

4. A source of microwaves of wavelength $\lambda$ is placed behind two slits, R and S. A microwave detector records the maximum response when it is placed at P, where RP = SP.




The microwave detector is moved and the **next** maximum is recorded at Q.
The path difference (SQ – RQ) must be

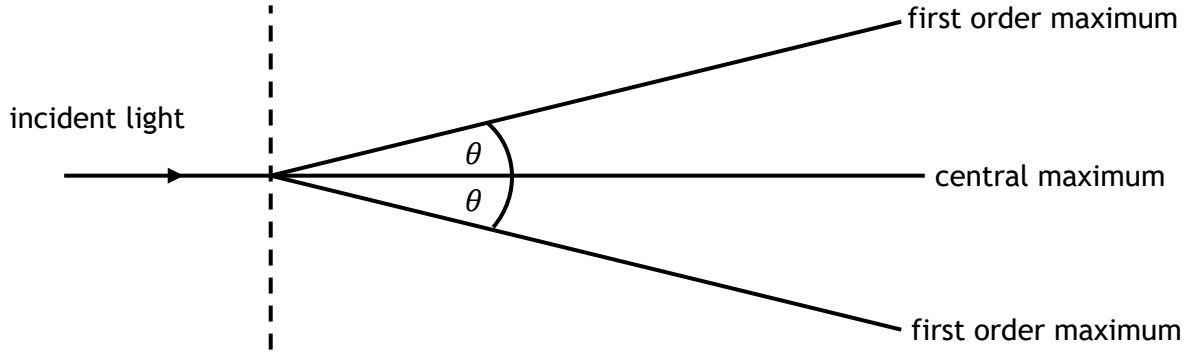
A 0
B $\frac{\lambda}{2}$
C $\lambda$
D (any odd number) $\times \frac{\lambda}{2}$
E (any whole number) $\times \lambda$

5. When a grating was set up to produce an interference patter on a screen using a monochromatic light source, the fringes were too close together to allow accurate measurement.

Identify which of the following changes would produce an increase in the separation of the fringes on the screen?

A Increasing the distance between the grating and the screen
B Using a grating with a greater separation of lines on it
C Using another light source of shorter wavelength
D Using anotjer light source of greater irradiance
E Increasing the distance between the source and the grating.

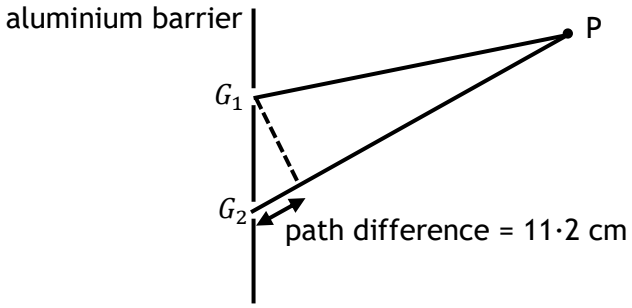
6. When monochromatic light is passes through a grating, a pattern of maxima and minima is observed as shown below.




Identify which row in the table represents the arrangement which would produce the greatest angle $\theta$ between the central maximum and the first order maximum.

| | Grating (lines per mm) | Colour of light |
|---|---|---|
| A | 100 | Red |
| B | 100 | Green |
| C | 100 | Blue |
| D | 200 | Red |
| E | 200 | Blue |

7. Microwaves of wavelength 2·8 cm pass through two narrow gaps $G_1$ and $G_2$ in an aluminium barrier. Point P on the par side of the barrier is 11·2 cm further from one gap than the other.

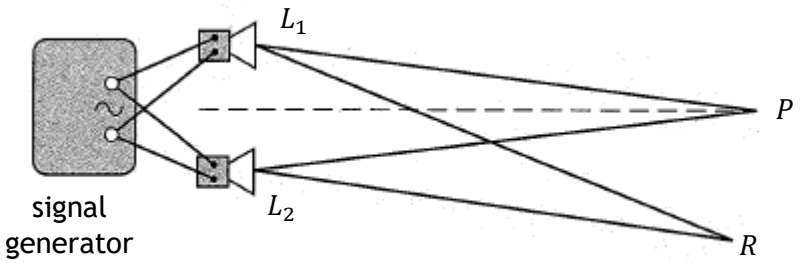



Which of the following statements about the radiation arriving at P from $G_2$ is/are true?

I It arrives in phase with the radiation from $G_1$
II It combines constructively with the radiation from $G_1$
III It has travelled a whole number of wavelengths further than the radiation from $G_1$

A II only
B III only
C I and II only
D II and III only
E I, II and III

8. Two identical loudspeakers, $L_1$ and $L_2$, are operated at the same frequency and in-phase with each other by connecting them in parallel across the output of a signal generator, as shown below. A sound interference pattern is produced.




At position $P$, which is the same distance from both loudspeakers, the microphone measures a maximum intensity of sound. The next maximum is registered at position $R$, where $L_1R = 4 \cdot 6\ m$ and $L_2R = 4 \cdot 3\ m$.
The speed of sound emitted by the loudspeakers is 340 $ms^{-1}$.
Identify the expression which would be used to calculate the frequency of the sound.

A $\frac{4 \cdot 6 - 4 \cdot 3}{340}\ Hz$

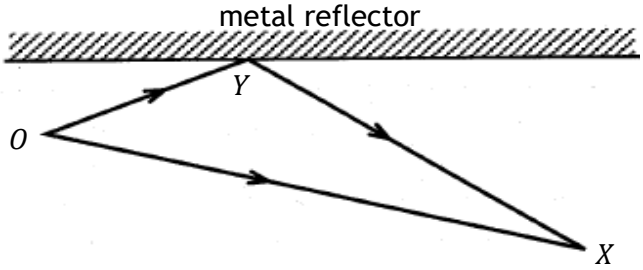
B $\frac{340}{4 \cdot 6 + 4 \cdot 3}\ Hz$

C $\frac{340}{4 \cdot 6 - 4 \cdot 3}\ Hz$

D $340 \times (4 \cdot 6 - 4 \cdot 3)\ Hz$

E $340 \times (4 \cdot 6 + 4 \cdot 3)\ Hz$

9. A microwave source at point $O$ produces waves of wavelength 28 mm. A metal reflector is placed as shown.



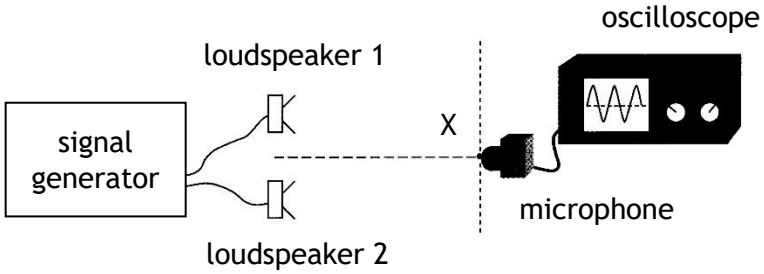

An interference pattern is produced.
**Constructive interference** occurs at point $X$. The distance $OX$ is 400 mm.
Calculate the path length $OYX$.

A 414 mm
B 421 mm
C 442 mm
D 456 mm
E 463 mm

10. Which row in the following table gives the approximate wavelengths of red, green and blue light?

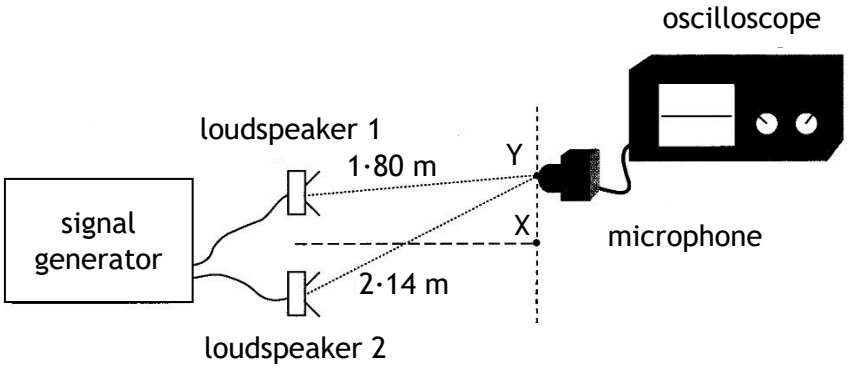
| | Red (nm) | Green (nm) | Blue (nm) |
|---|---|---|---|
| A | 700 | 540 | 450 |
| B | 700 | 450 | 540 |
| C | 900 | 700 | 540 |
| D | 700 | 540 | 300 |
| E | 450 | 540 | 700 |

11. A student is carrying out an experiment to investigate the interference of sound waves. She sets up the following apparatus.




The microphone is initially placed at point X, which is the same distance from each loudspeaker. A maximum is detected at X.

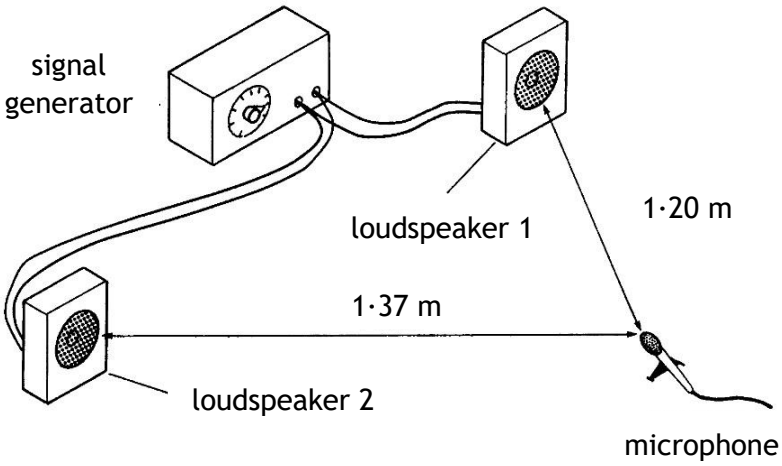
The microphone is now moved to the first minimum Y as shown.




(a) Calculate the wavelength of the sound waves.

(b) Loudspeaker 1 is now disconnected.
State what happens to the amplitude of the sound detected by the microphone at Y.
You must justify your answer.

12. Loudspeakers 1 and 2 are both connected to the same signal generator which is set to produce a 1·00 kHz signal.
Loudspeaker 1 is switched on but loudspeaker 2 is switched off.



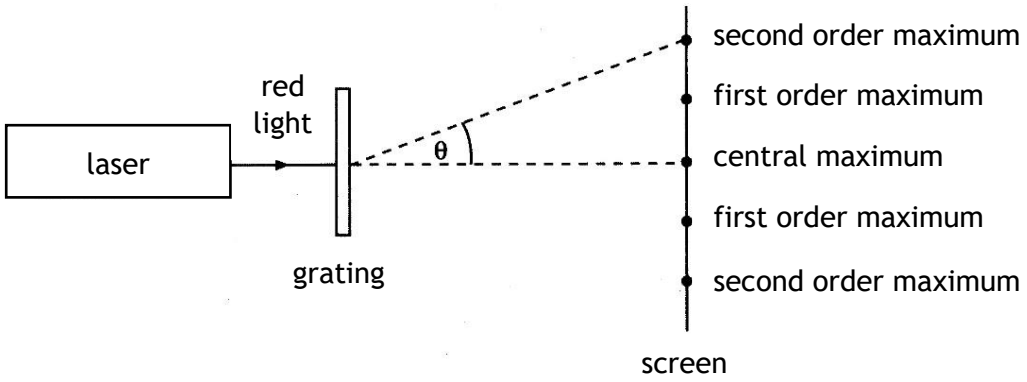

The speed of sound in air is 340 m $s^{-1}$.

State **and** explain what happens to the amplitude of the signal picked up by the microphone when loudspeaker 2 is switched on.

You must justify you answer by calculation.

13. A laser produces a narrow beam of monochromatic light.

(a) Red light from a laser passes through a grating as shown.

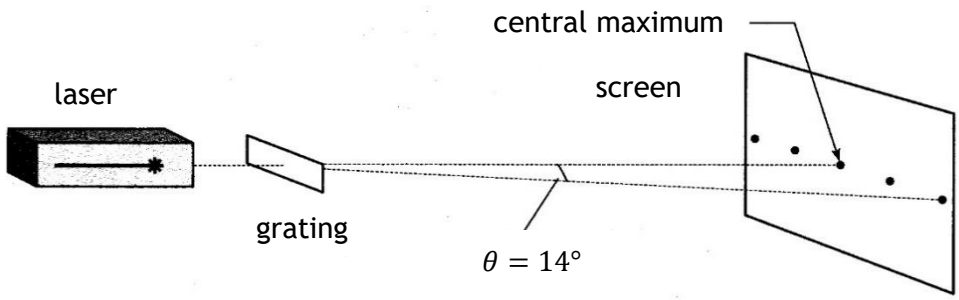



A series of maxima and minima are observed.
Explain in terms of waves how a minimum is produced.

(b) The laser is now replaced by a second laser, which emits blue light.
Explain why the observed maxima are now closer together.

(c) The wavelength of the blue light from the second laser is $4{\cdot}73 \times 10^{-7}$ m.
The spacing between the lines on the grating is $2{\cdot}00 \times 10^{-6}$ m.
Calculate the angle between the central maximum and the second order maximum.

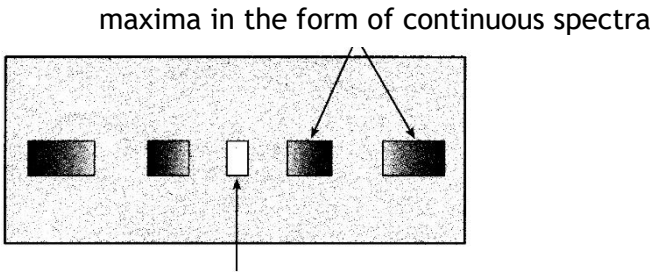
14. Light from a laser is shone onto a grating. The separation of the slits on the grating is $5{\cdot}0 \times 10^{-6}$ m. A pattern is produced on a screen as shown below.




(a) The angle θ between the central maximum and the 2nd order maximum is 14°.
Calculate the wavelength of the light produced by the laser.

(b) A pupil suggests that a more accurate value for the wavelength of the laser light can be found if a grating with a slit separation of $2{\cdot}0 \times 10^{-6}$ m is used.
Explain why this suggestion is correct.

(c) The laser is replaced by a source of white light and the pattern on the screen changes to a white central maximum with other maxima in the form of continuous spectra on each side of the central maximum.




Explain:

(i) why the central maximum is white;
(ii) why the other maxima are in the form of continuous spectra.