Worked Solutions for ENGAA Papers by Topic

Section 1

Topic: Waves

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ENGAA S1 2020 - Question 13

13 P and Q are two fixed points on the surface of the ocean which are 6.0 m apart.

An ocean wave travels in the direction P to Q.

The wave has a frequency of 0.50 Hz and travels at a constant speed.

A wave peak passes Q at time $t = 0$ s.

The next wave peak travelling towards Q passes P at time $t = 0.80$ s.

What is the speed of the wave?

A $2.1\,\text{ms}^{-1}$

B $3.4\,\text{ms}^{-1}$

C $5.0\,\text{ms}^{-1}$

D $7.5\,\text{ms}^{-1}$

E $20\,\text{ms}^{-1}$

ENGAA S1 2020 - Question 13 - Worked Solution

d = 6m

$f = \frac{1}{2}$

T = 2S

t = 0

t = 0.8

$\frac{0.8}{2} = \frac{2}{5}\ of\ a\ wave$

$6m = \left(1 - \frac{2}{5}\right)\lambda$

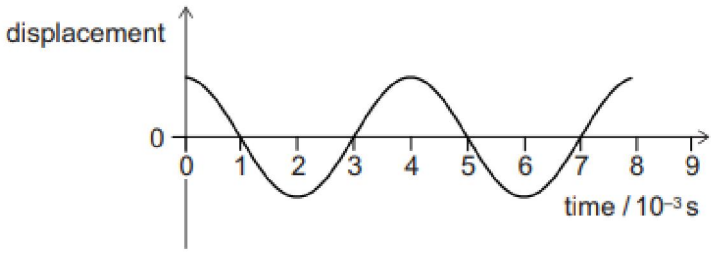
λ = 10m

$v = f\lambda = 10 \times 0.5 = 5mS^{-1}$

Answer is C

ENGAA S1 2020 - Question 25

25 The graph shows how the displacement due to a wave in air varies with time.



The speed of the wave in air is $300\,\text{m s}^{-1}$.

The wave now travels into water.

$$\frac{\text{wave speed in air}}{\text{wave speed in water}} = 0.2$$

What is the wavelength of the wave in water?

A $\frac{1}{6}$ m

B $\frac{2}{9}$ m

C $\frac{5}{6}$ m

D $\frac{9}{10}$ m

E $\frac{10}{9}$ m

F $\frac{6}{5}$ m

G $\frac{9}{2}$ m

H 6 m

ENGAA S1 2020 - Question 25 - Worked Solution

$$v_a = f\lambda_a$$

$$\lambda_a = \frac{300}{f} = \frac{300}{1/4 \times 10^{-3}} = 1.2m$$

$$\frac{v_a}{v_w} = 5\lambda_a = 5 \times 1.2m$$

$$\lambda_w = 6\text{m}$$

Answer is H

ENGAA S1 2019 - Question 4

4 Two electromagnetic waves P and Q travel in a vacuum and the ratio of their wavelengths is:

$$\frac{\text{wavelength of P}}{\text{wavelength of Q}} = 1.0 \times 10^{8}$$

Which row in the table shows the ratio of their speeds, the ratio of their frequencies, and identifies the possible natures of P and Q?

	$\frac{\textit{speed of P}}{\textit{speed of Q}}$	$\frac{\textit{frequency of P}}{\textit{frequency of Q}}$	*nature of* P	*nature of* Q
A	1.0	1.0×10^{-8}	microwave	X-ray
B	1.0	1.0×10^{-8}	microwave	radio wave
C	1.0	1.0×10^{8}	infrared	ultraviolet
D	1.0	1.0×10^{8}	visible light	infrared
E	1.0×10^{8}	1.0	gamma	X-ray
F	1.0×10^{8}	1.0	gamma	infrared
G	1.0×10^{8}	1.0×10^{16}	infrared	radio wave
H	1.0×10^{8}	1.0×10^{16}	visible light	ultraviolet

ENGAA S1 2019 - Question 4 - Worked Solution

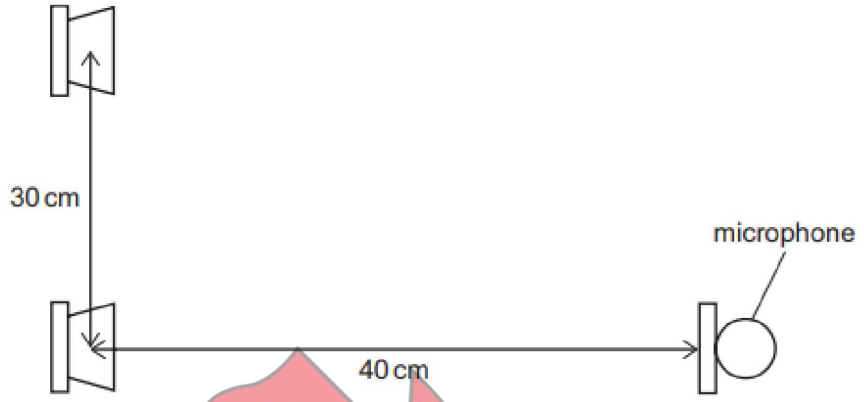
Answer is A

ENGAA S1 2019 - Question 30

30 Two small loudspeakers are placed side by side 30 cm apart.

They are connected to the same signal generator so that they emit sound of frequency 400 Hz in phase with one another.

The sounds both reach a microphone placed 40 cm directly in front of one of the two loudspeakers as shown.



What is the phase difference between waves from the loudspeakers as they arrive at the microphone?

(speed of sound – 320 m s^{-1})

A 30°

B 36°

C 45°

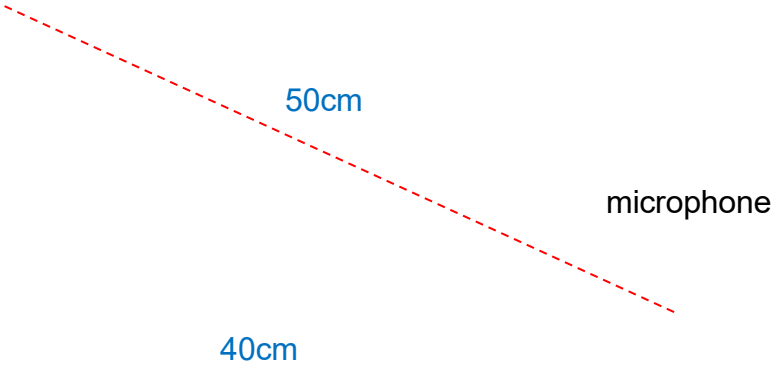
D 60°

E 72°

F 90°

G 120°

ENGAA S1 2019 - Question 30 - Worked Solution



10cm path difference

$$\lambda = \frac{320}{400Hz} = 0.8m = 80cm$$

$$\varphi = \frac{d}{\lambda} . 2\pi = \frac{10cm}{80cm} . 2\pi = \frac{\pi}{4}$$

$$or\ in\ degrees: \varphi = \frac{d}{\lambda} . 360° = \frac{10}{80} . 360° = 45°$$

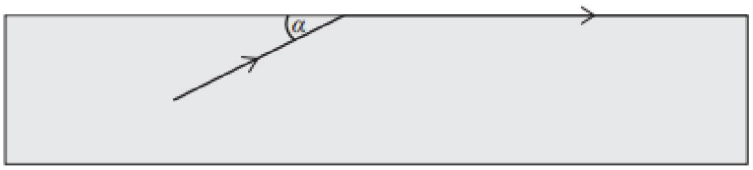
Think of the phase difference in this case as the fraction of wavelength the top wave has travelled extra

Answer is C

ENGAA S1 2019 - Question 38

38 Light travelling in a transparent liquid strikes the surface from below. The angle between the surface of the liquid and the direction of travel of the light is α.

The light then travels along the surface between the liquid and the air as shown in the diagram.



Now, light travelling in air strikes the surface from above so that the angle between the surface and the direction of travel of this light is also α.

After the light strikes the surface from above, the angle between the surface and the direction of travel of the refracted light is β.

Which expression gives β?

(all angles are in degrees)

A $\cos\beta = \cos^2\alpha$

B $\cos\beta = \cos\alpha \sin^{-1}\left(\frac{1}{\alpha}\right)$

C $\sin\beta = \sin^2\alpha$

D $\beta = 90 - (90 - \alpha)^2$

E $\beta = 0$

F $\beta = \alpha$

ENGAA S1 2019 - Question 38 - Worked Solution

By Snell's law

$$\sin\sin(90 - \alpha) = n \sin\sin(90 - \beta)$$

$$\text{Cos Cos } @ = n \text{ Cos Cos } @$$

Boundary condition

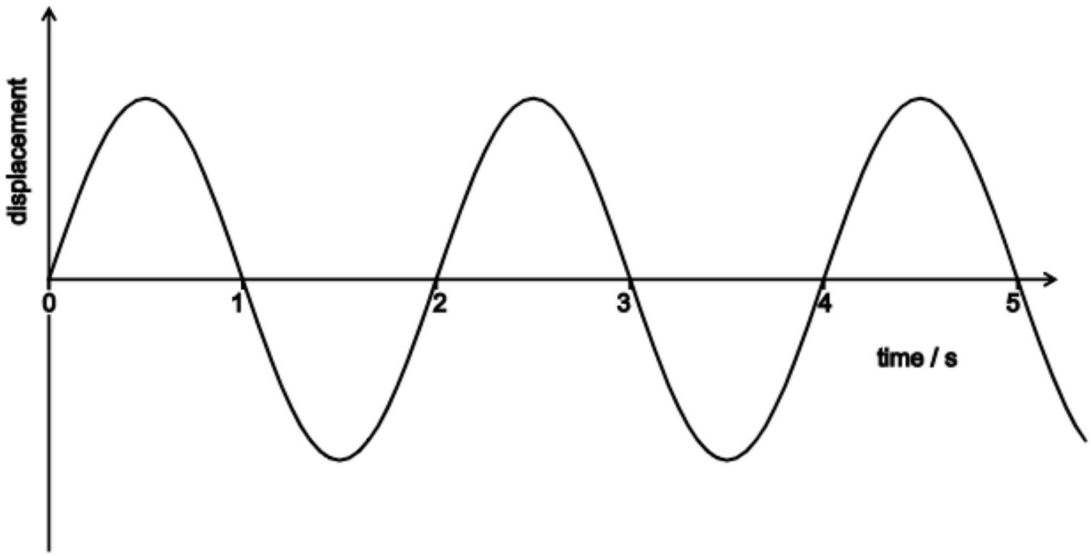
$$\sin\sin(90 - \alpha) = n \sin\sin(90 - 0) \rightarrow n = \frac{1}{cos\ cos\ ?}$$

Thus $\text{Cos}^2\alpha = \text{Cos Cos } @$

Answer is A

ENGAA Specimen S1 - Question 4

4 The displacement/time graph shown represents a wave of wavelength 1.5 cm.



What is the speed of the wave?

A $0.33\,cm\,s^{-1}$

B $0.67\,cm\,s^{-1}$

C $0.75\,cm\,s^{-1}$

D $1.33\,cm\,s^{-1}$

E $1.5\,cm\,s^{-1}$

F $3.0\,cm\,s^{-1}$

ENGAA Specimen S1 - Question 4 - Worked Solution

The period of the wave, T=2.0s

$$f = \frac{1}{T} = 0.5Hz$$

$$v = f\lambda$$
$$v = 0.5 \times 1.5$$
$$v = 0.75 cms^{-1}$$

Answer is C

ENGAA Specimen S1 - Question 14

14 A pulse of frequency 100 kHz is emitted from an ultrasound scanner, and is reflected from a foetus 10 cm below the transmitter placed on the mother's abdomen. The speed of sound within the mother's body is 500 m s^{-1}.

How long after its emission from the scanner does it take for the pulse to reach the receiver which is adjacent to the transmitter?

A 0.20 ms

B 0.40 ms

C 0.50 ms

D 0.80 ms

E 1.0 ms

ENGAA Specimen S1 - Question 14 - Worked Solution

The pulse travels to the foetus and back, totaling 20cm

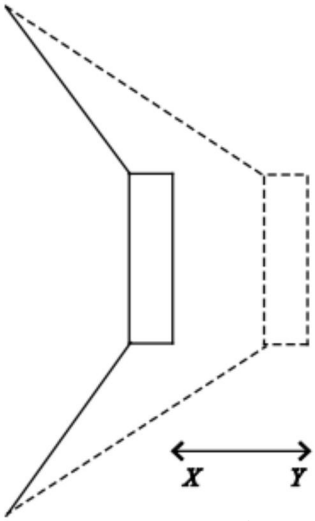
$$t = \frac{d}{v} = \frac{20 \times 10^{-2}}{500} = 4 \times 10^{-2} s = 0.40 ms$$

Answer is B

ENGAA Specimen S1 - Question 20

20 A sound wave is produced by a loudspeaker cone, which creates pulses of pressure by moving back and forth between two points X and Y as shown in the diagram.

[diagram not to scale]



The distance between points X and Y is 5.0 mm and the loudspeaker produces pulses of high pressure every 0.20 milliseconds.

The following statements about the sound wave produced are made:

P It has a speed of 25 m s^{-1}.

Q It has an amplitude of 5.0 mm.

R It has a wavelength of 5.5 mm.

S It has a frequency of 5.0 kHz.

Which of these statements can be correctly deduced from the information given?

A P only

B S only

C P and Q only

D P and R only

E Q and S only

F R and S only

G P, R and S only

ENGAA Specimen S1 - Question 20 - Worked Solution

$$T = 0.2mS = 2 \times 10^{-4}S$$

$$f = \frac{1}{T} = \frac{1}{2 \times 10^{-4}} = 5000Hz = 5kHz$$

We have no information about the speed of the waves.

We know the frequency but no way to know the wavelength

Answer is B

ENGAA S1 2018 - Question 6

6 When travelling in a vacuum, visible light has a wavelength between 400 nm and 700 nm.

The speed of light in a vacuum is $3.0 \times 10^8 \text{ms}^{-1}$.

What can be concluded about **ultraviolet** radiation from this information?

A It has a **maximum** frequency of 2.7×10^{14}Hz

B It has a **maximum** frequency of 4.3×10^{14}Hz

C It has a **maximum** frequency of 7.5×10^{14}Hz

D It has a **maximum** frequency of 1.0×10^{15}Hz

E It has a **minimum** frequency of 2.7×10^{14}Hz

F It has a **minimum** frequency of 4.3×10^{14}Hz

G It has a **minimum** frequency of 7.5×10^{14}Hz

H It has a **minimum** frequency of 1.0×10^{15}Hz

ENGAA S1 2018 - Question 6 - Worked Solution

Ultra light has max λ:

λ = 400m

$$c = \lambda f$$

$$f = \frac{c}{\lambda}$$

λ is a maximum so f will be a minimum

$$f = \frac{3.0 \times 10^8}{400 \times 10^{-9}}$$

$$= 7.5 \times 10^{14}\text{Hz}$$

Answer is G.

ENGAA S1 2018 - Question 18

18 A transverse wave with an amplitude of 4.0 cm and a frequency of 10 Hz travels along a rope at a speed of 2.4 m s^{-1}.

What is the total distance travelled by a particle in the rope in a time of 20 s?

A 2.4 m

B 4.8 m

C 8.0 m

D 16 m

E 32 m

F 48 m

ENGAA S1 2018 - Question 18 - Worked Solution

f = 10Hz

$$T = \frac{1}{f} = 0.1s$$

$$\frac{20}{T} = \frac{20}{0.1} = 200$$

SO in 20s, 200 waves pass particle

In one wave particle travels 4 × 4.0 cm

In 200 waves : distance = 4 × 4.0 × 200

= 3200cm

= 32m

Answer is E.

ENGAA S1 2018 - Question 28

28 Three detectors X, Y and Z are separated by large distances.

Each of the detectors records a seismic wave from the same earthquake whose epicentre (source) is very close to the surface of the Earth.

The wave travels out from the epicentre at $4.0\,\text{km}\,\text{s}^{-1}$.

Detectors X and Y start to detect the wave at the same time, but detector Z starts to detect it one minute later.

Which of the following statements **must** be correct?

1 The epicentre is at the midpoint of the line XY.

2 Z is equidistant from X and Y.

3 Z is no more than 240 km away from X and from Y.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

ENGAA S1 2018 - Question 28 - Worked Solution

① Not necessary as:
② No, Z can be anywhere after X and Y.
③ No, as can be more than 240km

Answer is A.

ENGAA S1 2016 - Question 12

12 A transverse wave travelling through a medium has a frequency of 5.0 Hz, a wavelength of 4.0 cm and an amplitude of 3.0 cm.

What is the total distance travelled by a particle of the medium in one minute?

A 900 cm

B 1200 cm

C 1800 cm

D 2400 cm

E 3600 cm

F 4800 cm

ENGAA S1 2016 - Question 12 - Worked Solution

$v = f\lambda$ in the direction of the wave's motion

BUT particles in the motion have no net movement

During one complete cycle a particle in the medium will be displaced from 0 to A back to 0_1 to -A and finally back to 0.

This is a total distance of 4A.

This transverse $v = 4Af$

$$d = vt$$

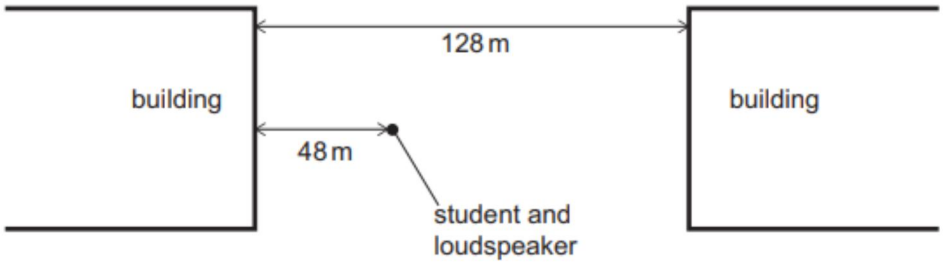
$$d = 4 \times 3.0 \times 5.0 \times 60$$

$$d = 3600\text{cm}$$

Answer is E

ENGAA S1 2016 - Question 28

28 A student carries out an experiment to measure the speed of sound. A loudspeaker that emits sound in all directions is placed between two buildings that are 128 m apart as shown. The student and loudspeaker are 48 m from one of the buildings.



The loudspeaker is connected to a signal generator that causes it to emit regular clicks. The student notices that each click results in two echoes, one from each building. The rate at which the clicks are produced is gradually increased from zero until each echo coincides with a new click being emitted by the loudspeaker.

What is the frequency of emission of clicks when this happens?

(The speed of sound in air = $320\,m\,s^{-1}$.)

A 2.0 Hz

B 2.5 Hz

C 3.3 Hz

D 4.0 Hz

E 5.3 Hz

F 6.7 Hz

G 10 Hz

ENGAA S1 2016 - Question 28 - Worked Solution

The two buildings are 48m and 80m away from the student

Sound will have to travel 96 or 160m to echo which will take 0.3s or 0.5s

The time between clicks therefore has 0.3s or 0.5s.

The minimum frequency when a click coincides with an echo is 2.0Hz

However for both echoes to coincide with a click, the clicks must occur every 0.1s or at a frequency of 10.0Hz.

Answer is G.