National 5 - Waves & Radiation

1.1 Into to Waves

1. Light travels faster than sound

2 (a) Speed of Sound in air $= 340\ ms^{-1}$
(b) Speed of Light in air $= 3 \times 10^{8}\ ms^{-1}$

3. $v = ?$
$d = 45 \times 10^{3}\ m$
$t = 30s$

$v = \frac{d}{t}$

$v = \frac{45\ 000}{30}$

$v = 1500\ ms^{-1}$

4. Connect 2 microphones to a timer, measure distance 1m with a ruler between microphones.
Make loud sound, when sound reaches 1st microphone timer starts & when it reaches 2nd microphone timer stops
Use $v = \frac{d}{t}$ d = distance 1m
t = time for sound to travel 1m.

5. Sound travels by particle vibrations. In a vacuum there are no particles

6. $v = 340\ ms^{-1}$
$d = ?$
$t = 6s$

$v = \frac{d}{t}$

$340 = \frac{d}{6}$

$d = 340 \times 6$

$d = 2040m$

7. $v = 340\ ms^{-1}$
$d = 19.8 \times 10^3$
$t = ?$

$v = \frac{d}{t}$

$340 = \frac{19.8 \times 10^3}{t}$

$t = \frac{19.8 \times 10^3}{340}$

$t = 58.2s$

8. a) $6km \rightarrow m$ $6 \times 10^3 m$ or $6000m$

b) $200\,mm \rightarrow m$ $200 \times 10^{-3} m$ or $0.2m$

c) $660nm \rightarrow m$ $660 \times 10^{-9} m$

d) $0.4ms \rightarrow s$ $0.4 \times 10^{-3} s$

9. $t = 1.2s$
$v = 3 \times 10^8 ms^{-1}$
$d = ?$

$v = \frac{d}{t}$

$3 \times 10^8 = \frac{d}{1.2}$

$d = 3 \times 10^8 \times 1.2$
$d = 3.6 \times 10^8 m$

10. $v = 3 \times 10^8 ms^{-1}$
$d = 1.49 \times 10^{11} m$
$t = ?$

$v = \frac{d}{t}$

$3 \times 10^8 = \frac{1.49 \times 10^{11}}{t}$

$\frac{1.49 \times 10^{11}}{3 \times 10^8} = t$

$t = 497s$

11. Waves transfer Energy.

12)b) $d = 1.5 \times 10^3 m.$
$v = 340 ms^{-1}$
$t = ?$

$v = \frac{d}{t}$

$340 = \frac{1.5 \times 10^3}{t.}$

$t = \frac{1.5 \times 10^3}{340} \Rightarrow t_2 = 4.41s$

$\Delta t = t_2 - t$
$= 4.41 - 0.29$
$= 4.12s$

12.) a) $d = 1.5 \times 10^3 m$
$v = 5050 ms^{-1}$
$t = ?$

$v = \frac{d}{t}$

$5050 = \frac{1.5 \times 10^3}{t}$

$t = \frac{1.5 \times 10^3}{5050}$

$t = 0.29s$

13) $v = 340 ms^{-1}$
$d = 6m$
$t = ?$

$v = \frac{d}{t}$

$340 = \frac{6}{t}$

$t = \frac{6}{340}$

$t = 0.018s$

b) a loud speaker is place in each lane, therefore the signal travels at $3 \times 10^8 ms^{-1}$ to each lane

14) $t = 4.4s$
$v = 340 ms^{-1}$
$d = ?$

$v = \frac{d}{t}$

$340 = \frac{d}{4.4}$

$d = 340 \times 4.4$

$d = 1496m$

15) **5 m away**

$v = \frac{d}{t}$

$340 = \frac{5}{t}$

$t = \frac{5}{340}$

$t_1 = 0.015$

15m away

$v = \frac{d}{t}$

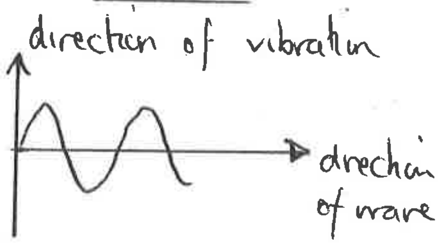
$340 = \frac{15}{t}$

$t = \frac{15}{340}$

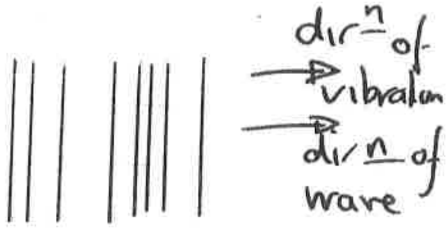
$t_2 = 0.044s$

time difference = $0.044 - 0.015 = 0.029s$

16) Transverse : particle vibrates at 90° to the direction of travel of the wave



Longitudinal : particle vibrates in same direction as the travel of the wave



17) a) Transverse waves : All electromagnetic waves.
b) Longitudinal wave : Sound waves

18) (i) DIFFRACT /BEND
(ii) DIFFRACT
(iii) MORE

19) Show your teacher

Wavespeed

22) (a) $f = \frac{60}{6}$

$f = 10 Hz$

(b) $f = \frac{2}{8}$

$f = 0.25 Hz$

(c) $f = \frac{0.5}{0.5}$

$f = 1 Hz$

(d) $f = \frac{180}{180}$

$f = 1 Hz$

20) Frequency is the number of waves passing a point every second.

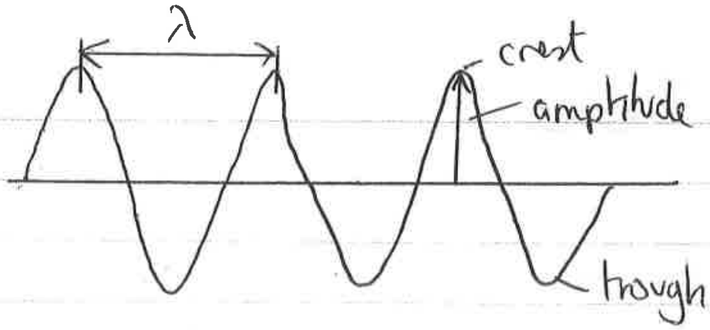
21) Hertz, Hz

23 $f = \frac{\text{No. of Vibrations}}{\text{time taken}}$

$f = 56 = \frac{\text{No of Vibrations}}{10}$

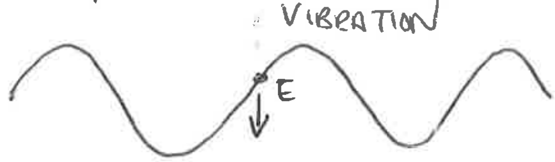
No. of Vibrations $= 56 \times 10$

$= 560$ Vibrations

24. 

25. (a) 3 waves
(b) 2 waves
(c) 4 waves
(d) 2½ waves

26. Wavelength = 6m
Amplitude = 0.1m

27. (a) Crest ⇒ B
(b) Trough ⇒ D
(c) 1 λ apart ⇒ E and H
(d) λ = 47mm
(e) amplitude = 14mm
(f) 

28. (a) 9/2 = 4.5cm
(b) λ = 3 cm
(c) A → B = 1.5 wavelengths = 4.5cm

29. λ = 100cm
(a) distance travelled in 4s = 3×100 = 300cm
(b) $v = \frac{d}{t}$

$v = \frac{0.3}{4}$

$v = 0.075 \; ms^{-1}$

30 (a) 6 km → m ⇒ 6×10^3 m

(b) 200 → m ⇒ $200 \times 10^{-}$ m or 0.2m.

(c) 45 GHz → Hz ⇒ 45×10^9 Hz

(d) 0.4 kHz → Hz ⇒ 0.4×10^3 Hz

Wave Equation

31. (a) $f = \frac{\text{No of Waves passing}}{\text{time taken}}$

$f = \frac{150}{60}$

$f = 2.5$ Hz

(b) Wavelength = 0.24/3 = 0.08m.

(c) $v = f\lambda$

$v = 2.5 \times 0.08$

$v = 0.2 ms^{-1}$

32.

Wave term	Symbol	Unit	Definition
Frequency	f	Hz	No. of waves passing a point every second
Wavelength	λ	m	from a pt on 1 wave to same pt on next wave
wavespeed	v	ms^{-1}	The distance travelled by a wave every second

33. $f = \frac{\text{No. of waves passing}}{\text{time taken}}$

$f = \frac{30}{60}$

$f = 0.5 Hz$

(b) ~~$v = f\lambda$~~ $v = \frac{d}{t}$ $v = \frac{24}{12}$

$v = 2 ms^{-1}$

34. $v = f\lambda$

$= 5 \times 11$

$v = 55 ms^{-1}$

38) $v = 3 \times 10^8 ms^{-1}$

$\lambda = 102.49 Hz$

$v = f\lambda$

$3 \times 10^8 = f \times 102.49$

$\frac{3 \times 10^8}{102.49} = f$

$f = 2.93 \times 10^6 Hz$

35) $v = 3 \times 10^8 ms^{-1}$

$\lambda = 60 \times 10^{-3} m$

$f = ?$

$v = f\lambda$

$3 \times 10^8 = f \times 60 \times 10^{-3}$

$\frac{3 \times 10^8}{60 \times 10^{-3}} = f$

$f = 5 \times 10^9 Hz$

36) (a) 1215 kHz → Hz ⇒ $1215 \times 10^3 Hz$

(b) 810 kHz → Hz ⇒ $810 \times 10^3 Hz$

(c) 548 kHz → Hz ⇒ $548 \times 10^3 Hz$

(d) 88 MHz → Hz ⇒ $88 \times 10^6 Hz$

(e) 97.6 MHz → Hz ⇒ $97.6 \times 10^6 Hz$

(f) 850 MHz → Hz ⇒ $850 \times 10^6 Hz$

37) $v = f\lambda$

$340 = f \times 1.3$

$\frac{340}{1.3} = f$

$\underline{\underline{261.5\,Hz = f}}$

39) $v = f\lambda$

$340 = 283 \times \lambda$

$\frac{340}{28} = \lambda$

$\underline{\underline{\lambda = 1.2m}}$

40 (a) $f = \frac{\text{No of waves passing}}{\text{time taken}}$

$f = \frac{20}{10}$

$\underline{\underline{f = 2\,Hz}}$

(b) $v = f\lambda$

$= 2 \times 1.2$

$\underline{\underline{v = 2.4\,ms^{-1}}}$

(c) Max displacement = $\underline{\underline{0.3m}}$

41) a) $v = \frac{d}{t}$

$v = \frac{1.2}{60}$

$\underline{\underline{v = 0.02\,ms^{-1}}}$

(b) $v = f\lambda$

$0.02 = f \times 0.05$

$\frac{0.02}{0.05} = f$

$\underline{\underline{f = 0.4\,Hz}}$

42. (a)

$$v = \frac{d}{t}$$

$$= \frac{34}{2.5}$$

$$v = 13.6\ Kmhr^{-1}$$

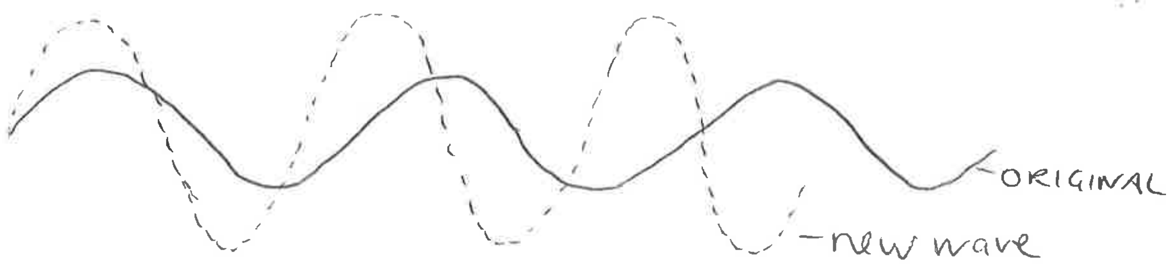
(b)

$$f = \frac{\text{No. of waves passing}}{\text{time taken}}$$

$$f = \frac{8}{10}$$

$$f = 0.8Hz$$

(c)



43. Underestimate
Runners will start when they hear gun. The sound then travels 100m to the line & then the timer will start their watches

(b) Loudspeakers behind each line and linked to timer too.

44. (a) Sound waves are LONGITUDINAL

(b) $v = \frac{d}{t}$

$340 = \frac{51}{t}$

$t = \frac{51}{340}$

$t = 0.15s$

(c) Waves transfer ENERGY

45. (a) Speed of Ultrasound in water = $1500ms^{-1}$

(b) $v = \frac{d}{t}$

$1500 = \frac{d}{0.1}$

$d = 1500 \times 0.1$ 0.1s = time to reach seabed

$d = 150m$

(c) $v = f\lambda$

$1500 = 30 \times 10^3 \times \lambda$

$\frac{1500}{30 \times 10^3} = \lambda$

$\lambda = 0.05m$

46. (a) $v = \frac{d}{t}$

$v = \frac{24}{20}$

$v = 1.2ms^{-1}$

(b) $f = \frac{\text{No of waves passing}}{\text{Time taken}}$

$f = \frac{5}{20}$

$f = 0.25 Hz$

(c) $v = f\lambda$

$1.2 = 0.25 \times \lambda$

$\frac{1.2}{0.25} = \lambda$

$\lambda = 4.8m$

or 5 waves in 24m ∴ 24/5 = 4.8m

47. (a) $v = f\lambda$

$340 = 2 \times 10^3 \times \lambda$

$\lambda = 0.17m$

(b) $v = \frac{d}{t}$

$340 = \frac{10.2}{t}$

$t = \frac{10.2}{340}$

$t = 0.03s$ to reach wall

$t = 0.06s$ to return to loudspeaker

(c) Speed of sound in Carbon dioxide = $270 ms^{-1}$

$v = f\lambda$

$270 = 2 \times 10^3 \times \lambda$

$\frac{270}{2 \times 10^3}$

$\lambda = 0.135m$ ∴ λ has decreased.

1.2 Electro Magnetic Spectrum

1a) highest frequency is Gamma
highest energy is Gamma

2(a)

RADIO	MICROWAVE	INFRA RED	VISIBLE	ULTRA VIOLET	X-RAYS	GAMMA

(b) lowest freqreny is Radio

3. All waves in Electromagnetic Spectrum travel at $3 \times 10^8 ms^{-1}$

4. $v = f\lambda$

$3\times10^8 = f \times 632.8 \times 10^{-9}$

$f = \frac{3\times10^8}{632.8\times10^{-9}}$

$f = 4.74 \times 10^{14} Hz$

5.

TYPE OF RADIATION	DETECTOR	USES / APPLICATIONS
RADIO & TV	electronic circuits	communications
MICROWAVE	electronic circuits	communications / heating food
INFRA RED	sun / warm objects	TV remote, treating injuries
VISIBLE	sun / warm objects	to see things
ULTRA VIOLET	sun / very hot objects	treat skin conditions / make vit D
X-RAYS	fast electron strike metal	detect broken bones
GAMMA	radioactive decay	sterilisation, tracers.

6. Radiation emitted by the sun is INFRA RED, Visible, Ultraviolet

7. Electronic circuits emit TV, radio & microwaves.

8) a) (i) $v = 3\times10^8 ms^{-1}$

(ii) $v = \frac{d}{t}$

$$3\times10^8 = \frac{20200\times10^3}{t}$$

$$t = \frac{20200\times10^3}{3\times10^8}$$

$$t = 6.7\times10^{-2} s$$

(iii) $v = f\lambda$

$$3\times10^8 = 1228\times10^6\times\lambda$$

$$\frac{3\times10^8}{1228\times10^6} = \lambda$$

$$\lambda = 0.24m$$

b) Short $\lambda \Rightarrow$ bigger frequency

∴ 1575MHz has the shortest λ

9) a) I) 15μs

II) $d = vt$

$= 5200\times15\times10^{-6}$

$= 0.078m$

b) I) $f = \frac{1}{T}$

$= \frac{1}{4\times10^{-6}}$

$= 2.5\times10^5 Hz$

II) $v = f\lambda$

$5200 = 2.5\times10^5\times\lambda$

$\lambda = \frac{5200}{2.5\times10^5}$

$= 0.0208m$

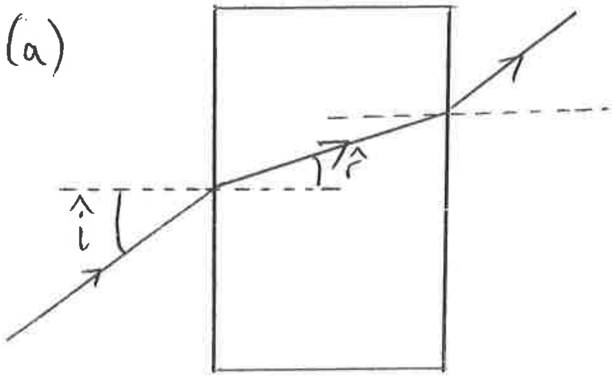
c) The speed of ultrasound is less than the speed in steel.

Because it takes a longer time to travel the same distance.

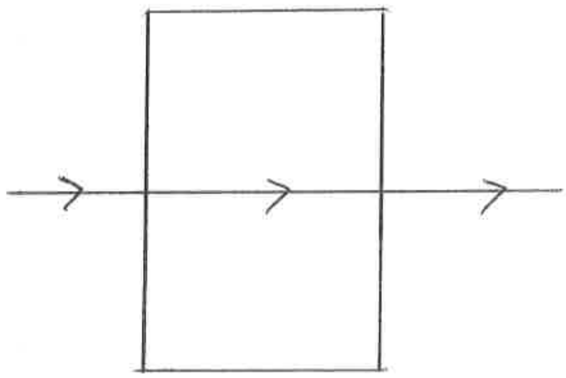
1.3 Light

1. Refraction is when light changes speed (& sometimes direction) as it enters a material of different optical density.

2. (a)

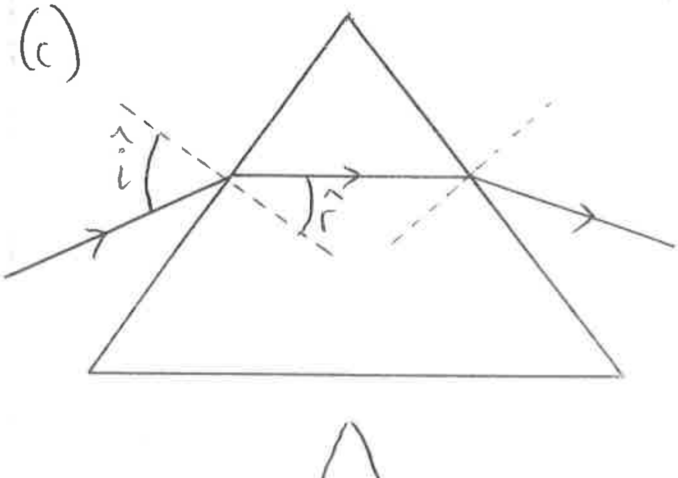


(b)

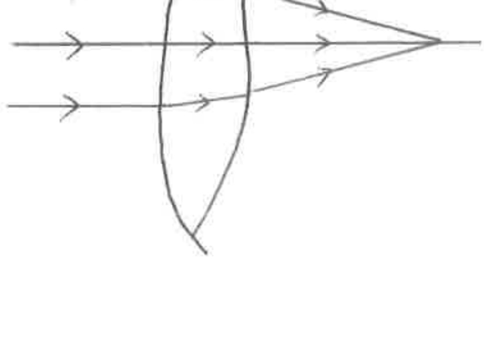


light travels along the normal

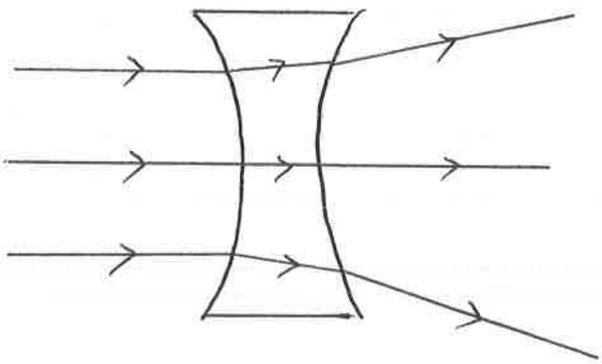
(c)



3.



(b)



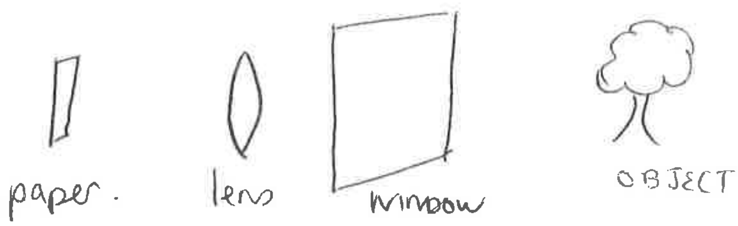
(c) If a thinner convex lens were used in part (a) the focal point would be further from the lens.

4. Air → Glass <u>towards</u> the normal

Glass → Air <u>away</u> from the normal

5. (a) Angle of incidence = Z
(b) Angle of refraction = X

6. Using light from a distant object (to ensure it is parallel) form a clear image on a piece of card by placing the lens in front of the card. (b) When a clear image is formed measure the distance between the lens and the card with a ruler

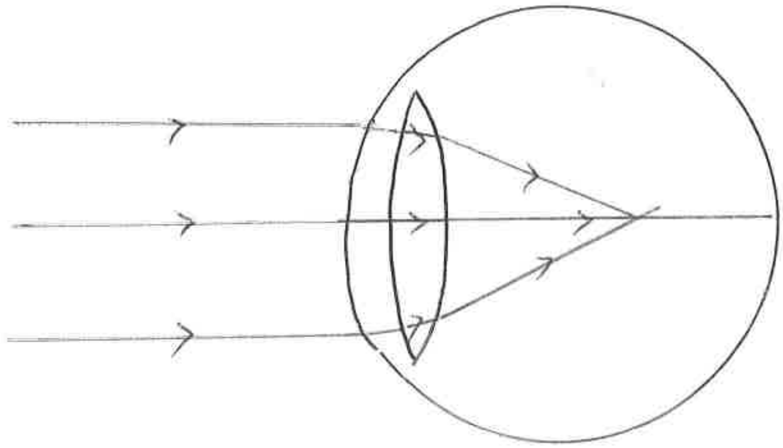


7.) (a) Concave / diverging
(b) To watch a movie
(c) Infront of retina

8.

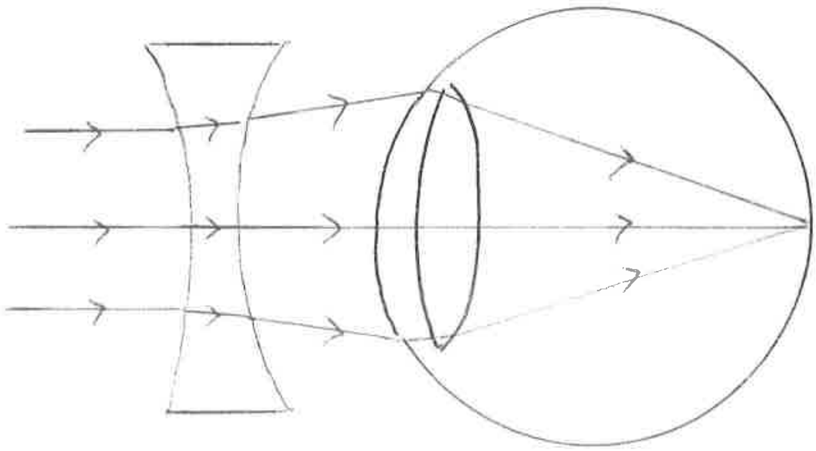
DEFECT	DESCRIPTION	LENS USED
LONG SIGHT	CAN NOT SEE CLOSE OBJECTS CLEARLY	CONVEX / CONVERGING
SHORT SIGHT	CAN NOT SEE DISTANT OBJECTS CLEARLY	CONCAVE / DIVERGING

9.



Distant light focused before retina

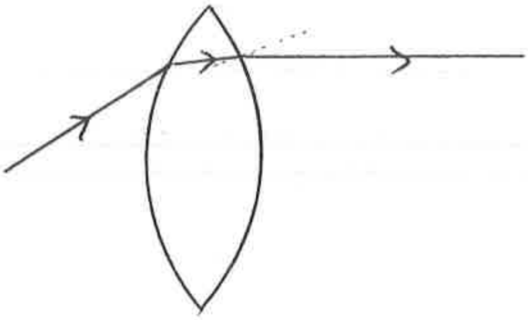
10.



Concave lens spreads light at more first.

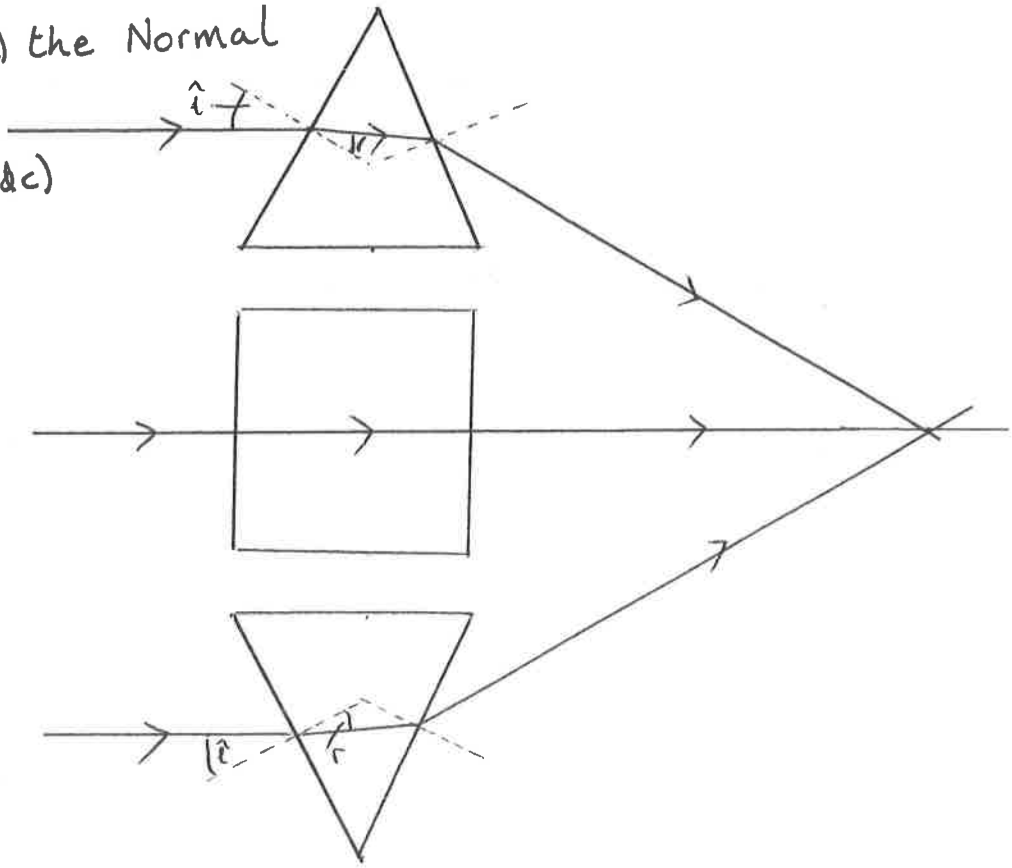
11 (a) long sight is when ~~bright~~ a person can not see near by objects clearly

(b)



12. a) the Normal

b)&c)

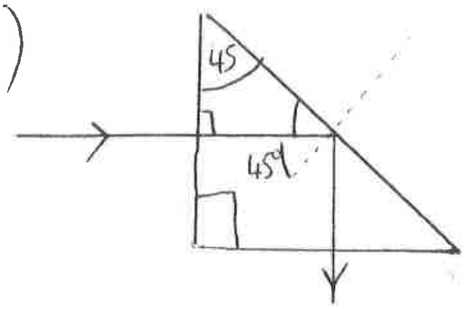


(d) Same effect as a Convex / Converging lens.

13. Critical angle = 37°

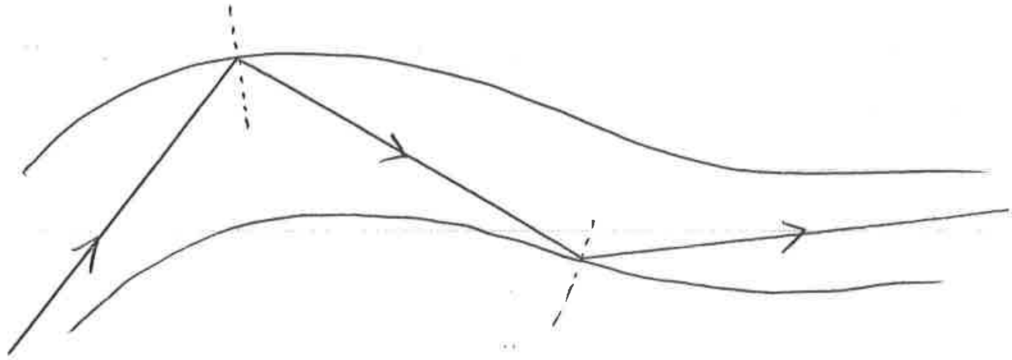
14. X shows total internal reflection

(b)



Critical angle will be approx 40° → 44°

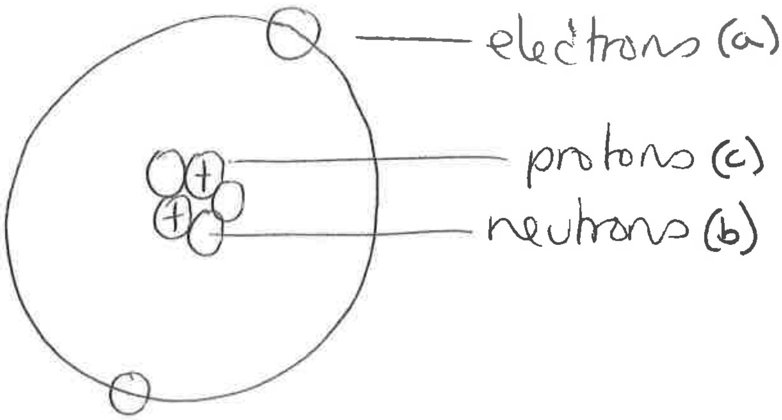
15.



16. Telecommunication & Endoscope use optical fibers.

1.4 Intro to Nuclear Radiation

1.



2.

Particle	Charge
Proton	Positive
Neutron	Neutral
Electron	Negative

3. Ionisation is when an atom gains or loses an electron leaving an overall positive or negative charge

4. Background Radiation - Natural Rocks, Cosmic Rays Humans.

5. Back grand radiation - Man made
Hospitals, power stations

6. C

7. Reduce time of exposure
Increase distance
Shielding

8. B

9.

NAME OF RADIATION	Symbol	WHAT IS IT?	IONISATION CAUSED	ABSORBED BY?
Alpha	α	Helium Nucleus	HIGH	PIECE OF PAPER
Beta	β	Electron	MEDIUM	FEW mm OF ALUMINIUM
Gamma	γ	EM radiation	LOW	SEVERAL cm OF LEAD

10. (a) at X will be gamma
(b) at Y will be gamma.

1.5 Activity, Half Life and Safety

Activity

1) The activity of the source is the number of radioactive decays per second.

2) Becquerels (Bq)

3) a) $2\,kBq = 2 \times 10^3\,Bq = 2000\,Bq$

b) $18\,MBq = 18 \times 10^6\,Bq = 18\,000\,000\,Bq$

4) $A = \frac{N}{t}$

$= \frac{210}{60}$

$= 3.5\,Bq$

5) $A = \frac{N}{t}$

$= \frac{1800}{180}$

$= 10\,Bq$

6) $A = \frac{N}{t}$

$= \frac{2400}{120}$

$= 20\,Bq$

7) $A = 0.4$

8) $A = \frac{N}{t}$

$2 \times 10^3 = \frac{N}{30}$

$N = 2 \times 10^3 \times 30$

$= 6 \times 10^4$ decays or 60000 decays

9) $A = \frac{N}{t}$

$1.8 \times 10^6 = \frac{8.1 \times 10^8}{t}$

$t = \frac{8.1 \times 10^8}{1.8 \times 10^6}$

$= 450\,s$

Half-Life

1) The time taken for the activity of a source to fall to half its current value.

2) Use a Geiger-Muller tube to measure the background radiation in 30s.
Take regular readings of the number decays from the source in 30s
Subtract the background radiation from all the results.
Draw a graph of number of decays against time to find the half-life

3) IA = 48kBq
FA = ?
hl = 2mins
t = 10mins

$\frac{10}{2} = 5$

48 →(1) 24 →(2) 12 →(3) 6 →(4) 3 →(5) 1.5

1.5kBq

4) IA = 800Bq
FA = ?
hl = 4 mins
t = 12mins

$\frac{12}{4} = 3$

800 →(1) 400 →(2) 200 →(3) 100

100Bq

5) IA = 160MBq
FA = ?
hl = 5hours
t = 15hours

$\frac{15}{5} = 3$

160 →(1) 80 →(2) 40 →(3) 20

20MBq

6) IA = 36 Bq
FA = $\frac{36}{8}$ = 4·5 Bq
hl = 300 years
t =

36 → 18 → 9 → 4.5 (1, 2, 3)

3 × 300 = 900 years

7) IA = 256 kBq
FA = ?
hl = 2·5 mins
t = 20 mins

$\frac{20}{2.5}$ 8

256 → 128 → 64 → 32 → 16 → 8 → 4 → 2 → 1 (1, 2, 3, 4, 5, 6, 7, 8)

1 kBq

8) IA = 2800 kBq
FA = 175 kBq
hl = ?
t = 8 mins

2800 → 1400 → 700 → 350 → 175 (1, 2, 3, 4)

$\frac{8}{4}$ = 2 minutes

9) hl = 70 s

1 → $\frac{1}{2}$ → $\frac{1}{4}$ → $\frac{1}{8}$ → $\frac{1}{16}$ → $\frac{1}{32}$ (1, 2, 3, 4, 5)

5 × 70 = 350 s

10) IA = 600 kBq
FA = 150 kBq
hl = ?
t = 10 days

600 → 300 → 150 (1, 2)

$\frac{10}{2}$ = 5 days

11) IA = ?
FA = 20 kBq
hl = 2 mins
t = 16 mins

$\frac{16}{2}$ = 8

20 → 40 → 80 → 160 → 320 → 640 → 1280 → 2560 → 5120 (1, 2, 3, 4, 5, 6, 7, 8)

5120 kBq

12) IA = ?
FA = 480 kBq
hl = 12 hours
t = 48 hours

$\frac{48}{12} = 4$

480 → 960 → 1920 → 3840 → 7680
(1, 2, 3, 4)

7680 kBq

13) a) 10 minutes

b) The time it takes for the activity of a source to fall to half its current value.

14) See graph on next page

hl = ~ 3 minutes

15) a) • Location in the world
• If you are inside or outside

b) $A = \frac{N}{t}$
$= \frac{4}{10}$
$= 0.4$ Bq

c) 4 minutes

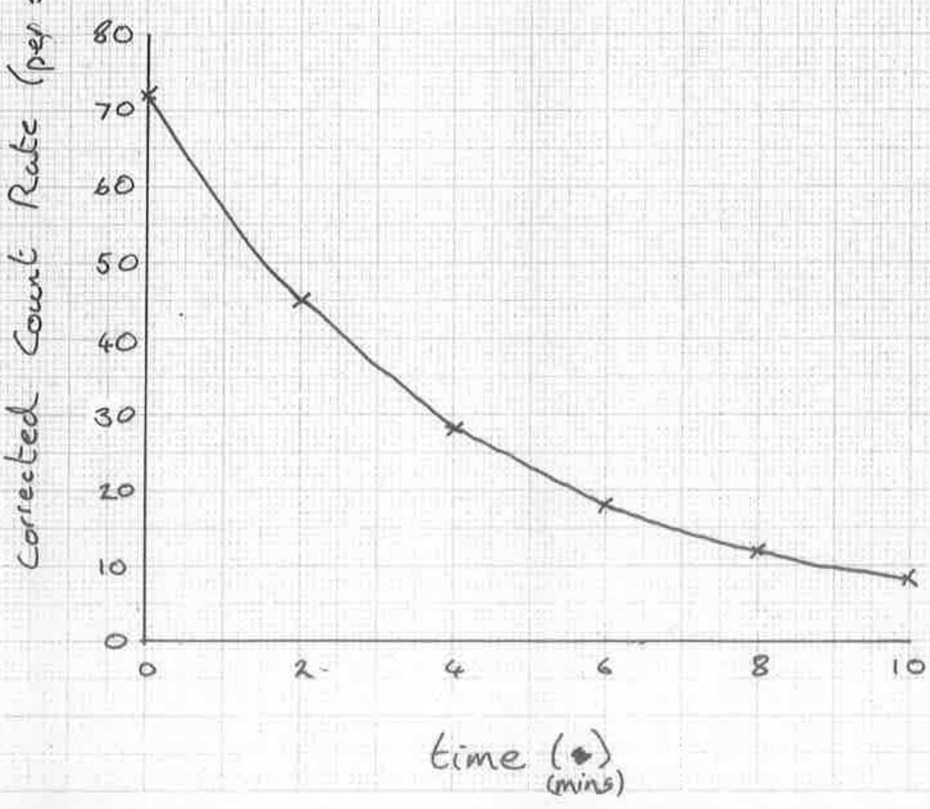
16) a) The activity of the carbon halves every 5730 years.

b) $\frac{17190}{5730} = 3$

1 → ½ → ¼ → ⅛
(1, 2, 3)

$\frac{1}{8}$

c) Becquerel (Bq)



Corrected Count Rate (per s)
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
time
(mins)

1·6 Dosimetry

1) a) $D = \frac{E}{m}$

$= \frac{50}{55}$

$= 0.9\,Gy$

b) $D = \frac{E}{m}$

$= \frac{50}{60}$

$= 0.83\,Gy$

c) Worker A because he has a smaller mass.

2) E $\quad D = \frac{E}{m} \quad \therefore \quad Gy = \frac{J}{kg}$

3) $D = \frac{E}{m}$

$3 \times 10^{-3} = \frac{1.8 \times 10^{-3}}{m}$

$m = \frac{1.8 \times 10^{-3}}{3 \times 10^{-3}}$

$= 0.6\,kg$

4) $D = \frac{E}{m}$

$= \frac{0.1}{0.05}$

$= 2\,Gy$ D

5) $D = \frac{E}{m}$

$= \frac{0.01}{0.1}$

$= 0.1\,Gy$

6) $D = \frac{E}{m}$

$= \frac{100}{55}$

$= 1.8\,Gy$

7) The radiation weighting factor is an indication of the biological harm done by a type of radiation.

8) a) $H = Dw_R$

$= 20 \times 10^{-3} \times 20$

$= 0.4\,Sv$

b)

9) $H = D w_R$

$1 \times 10^{-3} = 100 \times 10^{-6} \times w_R$

$w_R = \frac{1 \times 10^{-3}}{100 \times 10^{-6}}$

$= \underline{10}$

10) a) $D = \frac{E}{m}$

$= \frac{0.25}{50}$

$= \underline{0.005 \text{ Gy}}$

b) $H = D w_R$

$= 0.005 \times 20$

$= \underline{0.1 \text{ Sv}}$

11) $H = D w_R$

$= 20 \times 10^{-6} \times 20$

$= \underline{0.0004 \text{ Sv}}$

12) The part of the body affected

13) a) 2mSv per year b) 20 mSv per year

14)
- Limit time with the source
- Increase distance
- Shielding

15) Film badges use photographic film covered by different metals. When exposed to radiation the film turns black. Which sections of the film turn black shows the type of radiation.

16) a) Nuclear fusion is when small nuclei are combined to create larger nuclei and energy.

b) Nuclear fission is when large nuclei are bombarded with neutrons causing it to split into smaller nuclei and more neutrons.

c) Fusion

d) Fission

17)
- Expensive
- Possibility of Meltdown
- Radioactive waste

18)
- Rocks
- Animals
- Cosmic Rays
- Hospitals
- Power stations
- Nuclear weapon testing

19)
- The fuel is expensive and difficult to mine
- The process produces radioactive waste that is difficult to store.

20)
- Uranium contains far more energy per gram than fossil fuels
- It does not produce greenhouse gases which damage the enviroment.

21) a) I) $D = \frac{E}{m}$

$= \frac{6 \times 10^{-6}}{0.5}$

$= 1.2 \times 10^{-5}$ Gy

II) $H = Dw_R$

$= 1.2 \times 10^{-5} \times 20$

$= 2.4 \times 10^{-4}$ Sv

iii) $A = \frac{N}{t}$

$= \frac{24000}{5 \times 60}$

$= 80 Bq$

b) Fission