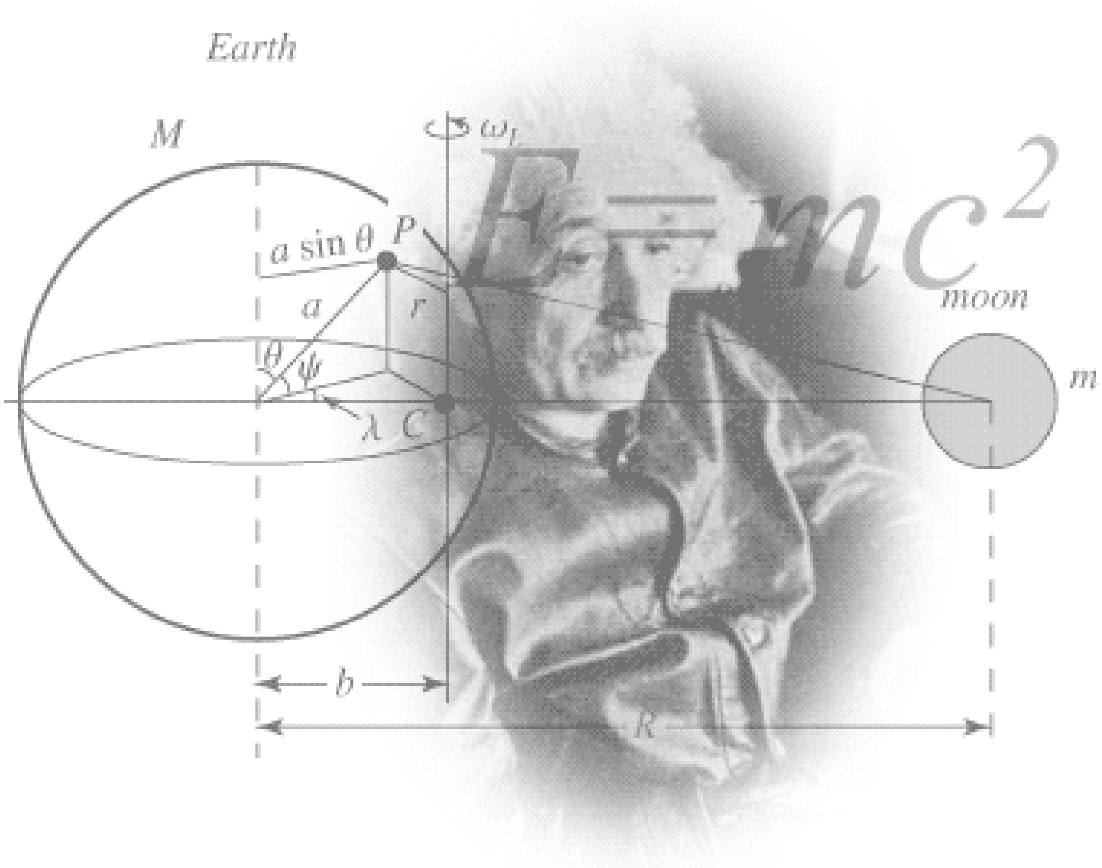
Galashiels Academy

CFE Higher Physics



Consolidation Questions

Name: ______________________________

Teacher: ______________________________

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in vacuum	c	$3{\cdot}00 \times 10^{8}\ \mathrm{m\,s^{-1}}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34}\ \mathrm{J\,s}$
Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}\ \mathrm{C}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}\ \mathrm{kg}$
Universal Constant of Gravitation	G	$6{\cdot}67 \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}\ \mathrm{kg}$
Gravitational acceleration on Earth	g	$9{\cdot}8\ \mathrm{m\,s^{-2}}$	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}\ \mathrm{kg}$
Hubble's constant	H_0	$2{\cdot}3 \times 10^{-18}\ \mathrm{s^{-1}}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	*Wavelength/nm*	*Colour*	*Element*	*Wavelength/nm*	*Colour*
Hydrogen	656	Red	Cadmium	644	Red
	486	Blue-green		509	Green
	434	Blue-violet		480	Blue
	410	Violet	Lasers		
	397	Ultraviolet	*Element*	*Wavelength/nm*	*Colour*
	389	Ultraviolet	Carbon dioxide	9550 }	Infrared
Sodium	589	Yellow		10590 }	
			Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	*Density/kg m^{-3}*	*Melting Point/K*	*Boiling Point/K*
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853
Ice	$9{\cdot}20 \times 10^{2}$	273	. . . .
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377
Water	$1{\cdot}00 \times 10^{3}$	273	373
Air	1·29	. . . .	. . . .
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^{5}$ Pa.

Relationships required for Physics Higher

$d = \bar{v}t$

$s = \bar{v}t$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

$W = mg$

$F = ma$

$E_W = Fd$

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$P = \frac{E}{t}$

$p = mv$

$Ft = mv - mu$

$F = G\frac{m_1 m_2}{r^2}$

$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$

$l' = l\sqrt{1 - \left(\frac{v}{c}\right)^2}$

$f_o = f_s\left(\frac{v}{v \pm v_s}\right)$

$W = QV$

$E = mc^2$

$E = hf$

$E_k = hf - hf_0$

$E_2 - E_1 = hf$

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

$v = f\lambda$

$d\sin\theta = m\lambda$

$n = \frac{\sin\theta_1}{\sin\theta_2}$

$\frac{\sin\theta_1}{\sin\theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$

$\sin\theta_c = \frac{1}{n}$

$I = \frac{k}{d^2}$

$I = \frac{P}{A}$

$V_{peak} = \sqrt{2}V_{rms}$

$I_{peak} = \sqrt{2}I_{rms}$

$Q = It$

$V = IR$

$P = IV = I^2R = \frac{V^2}{R}$

$R_T = R_1 + R_2 + \ldots.$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots.$

$E = V + Ir$

$V_1 = \left(\frac{R_1}{R_1 + R_2}\right)V_s$

$\frac{V_1}{V_2} = \frac{R_1}{R_2}$

$C = \frac{Q}{V}$

$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

path difference $= m\lambda$ or $\left(m + \frac{1}{2}\right)\lambda$ where $m = 0, 1, 2 \ldots$

random uncertainty $= \frac{\text{max. value} - \text{min. value}}{\text{number of values}}$

$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$

$z = \frac{v}{c}$

$v = H_0 d$

Questions	**Mark**	**Due Date**
1. Significant figures	/20	
2. Uncertainties	/20	
3. Vectors and Scalars	/20	
4. Equations of Motion	/20	
5. Velocity and Acceleration graphs	/20	
6. Forces	/20	
7. Momentum and Impulse	/20	
8. Gravitation	/20	
9. Special Relativity	/20	
10. The Doppler Effect	/20	
11. Redshift & Hubble's Law	/20	
12. AC Signals	/20	
13. Emf and Internal Resistance	/20	
14. Capacitors	/20	
15. Conductors, Semiconductors & Insulators	/20	
16. p-n junctions	/20	
17. The standard Model	/20	
18. Forces on a charged particle	/20	
19. Particle Accelerators	/20	
20. Fission and Fusion	/20	
21. Photoelectric Effect	/20	
22. Interference	/20	
23. Refraction	/20	
24. Spectra	/20	

1. Significant Figures

1. State the number of significant figures in each case.

a. 0.002 C
b. 234 900 N
c. 11.67130 F
d. 2.8 x 108 ms^{-1} **4**

2. Calculate the following and give your answers in scientific notation to 2 significant figures (e.g. 2.8 x 10^{4} etc)

a. Find the energy used by a 60 W bulb in 1 week
b. Find the frequency of light that has a wavelength of 4 x 10^{-9} m
c. Find the force on a 5 g ball accelerating at 0.1 ms^{-2} **6**

3. Write out the following numbers in full (e.g. 0.0456 etc)

a. 3 x 108 ms^{-1}
b. 6.02 x 10^{23} molecules
c. 2.489 x 10^{-4} N
d. 300 x 10^{2} m
e. 94523 x 10^{-5} kg **5**

4. Re-write the following using the most appropriate prefix (2.8 mA etc)

a. 0.000 005 Hz
b. 0.012 m
c. 40 000 V
d. 300 000 000 ms^{-1}
e. 2 000 000 000 000 kg **5**

Total 20 marks

2. Uncertainties

1. The length of a science lab is measured by 5 pupils, their results are shown below:
8.95 m, 9.02 m, 8.97 m, 8.82 m and 8.91 m

a. Calculate the mean of these values
b. Calculate the random uncertainty of the mean
c. Calculate the percentage uncertainty of the mean **6**

2. For the following readings calculate the percentage uncertainty.
Write your final answers as: Answer ± percentage uncertainty

a. Distance = 3.25 m ± 0.05 m
b. Time = 14.25 s ± 1.5 s
c. Voltage = 4.50 V ± 0.01 V
d. Resistance = 2516 Ω ± 1 Ω **4**

3. The specific heat capacity of a liquid was found by heating a measured quantity of the liquid for certain length of time. The following results were obtained.

Power = (100.0 ± 0.5) W
Mass = (500 ± 10) g
Time = (800 ± 1) s
Temperature change = (50.0 ± 0.5) ºC

a. Calculate the percentage error in each reading **4**
b. What will the approximate percentage error be in the value of the specific heat capacity? **2**
c. Suggest a way of reducing the total percentage error. **1**

4. A current is measured with an analogue meter which has scale divisions of 0.1 A, and is found to be 5.4 A. The reading is double-checked with a digital meter, and again is found to be 5.4 A.

a. Which instrument gives the larger scale reading uncertainty?
b. Explain your answer **3**

Total 20 marks

3. Vectors and Scalars

1. State the different between a Vector and a Scalar **1**

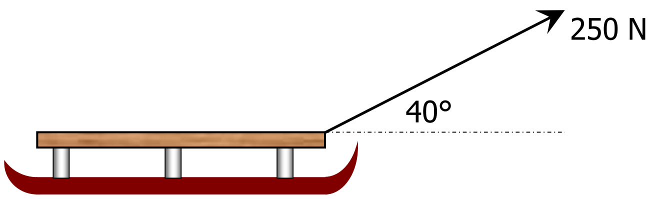
2. Arrange the following quantities into two lists under the headings vectors and scalars:
time, speed, force, weight, velocity, mass, displacement, distance, energy **2**

3. A cyclist rides his bike across a ship at 6 ms^{-1} due east as the ship sails 8 ms^{-1} south.
What is the resultant velocity of the cyclist? **2**

4. A boat sails across a river at a constant velocity of 4 ms^{-1} due west. The water flows at a constant velocity of 3 ms^{-1} due north. What is the resultant velocity of the boat? **2**

5. A farmer checking his fields walks 300 m due east and then 400 m due north.
- a. Find his distance travelled **1**
- b. Find his displacement **2**
- c. If he completes his walk in 15 minutes calculate:
  - i. His average speed **1**
  - ii. His average velocity **2**

6. A boy using a force of 250 N pulls a sledge across the snow as shown in the diagram. Calculate the horizontal and vertical components of this force **2**



7. A long jumper has a take-off velocity of 9 ms^{-1}, at an angle of 30° to the horizontal.
He is in the air for 0.8 s. Calculate:
- a. the horizontal component of velocity. **2**
- b. the vertical component of velocity. **2**
- c. the length of the jump. **1**

Total 20 marks

4. Equations of Motion

1. A racing car enters the final straight at 30 ms^{-1} and accelerates towards the finishing line at 1.5 ms^{-2}. If the finish line was 210 m away when the car started accelerating, how long did it take for the car to finish? **2**

2. A car is 30 m away from a set of traffic lights. If it is travelling at 10 ms^{-1} and decelerates at 1.75 ms^{-2}, will the car stop before the traffic lights? **2**

3. A toy car travels at 3 ms^{-1} and accelerates at 1.5 ms^{-2} for 5 s. What distance is covered during the time the car was accelerating? **2**

4. A rocket powered car is starts from rest and accelerates uniformly for 20 s. It reaches a velocity of 36 ms^{-1} after only 4 s.

a. What is the acceleration of the car? **2**

b. What is the velocity of the car after 20 s? **2**

c. How far does the car travel in 20 s? **1**

5. A ball thrown vertically upwards reaches a height of 50m

a. What was its initial velocity? **2**

b. How long did it take to reach its highest point? **2**

c. What was its velocity after 4s? **2**

6. A cannon ball is fired from a 35 m cliff.

a. How long will it take to hit the ground? **2**

b. If its vertical velocity is initially 30 ms-1, how far from the cliff will the ball land? **1**

Total 20 marks

5. Velocity and Acceleration Graphs

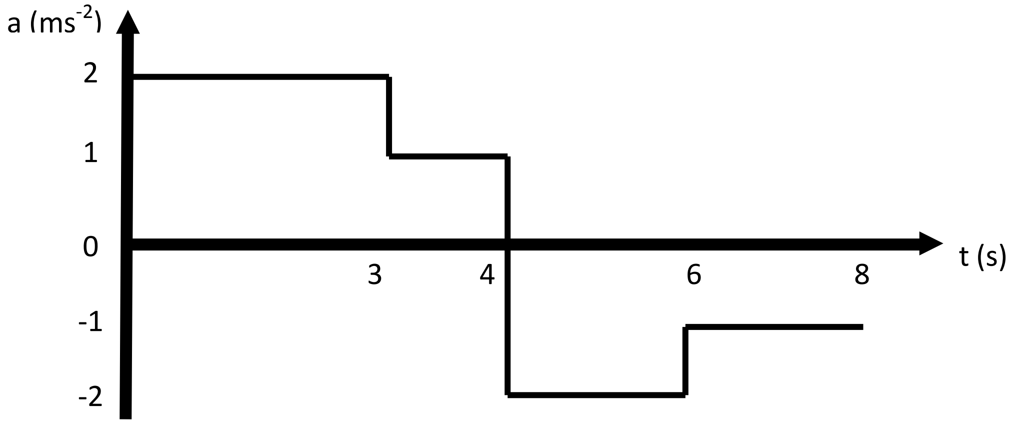
1. Sketch the following graphs:

a. A velocity-time graph of a ball being bounced once on the floor **3**

b. An acceleration-time graph for a lift moving from the ground floor to the 3rd floor of a building, without it stopping at floor 1 or floor 2. **3**

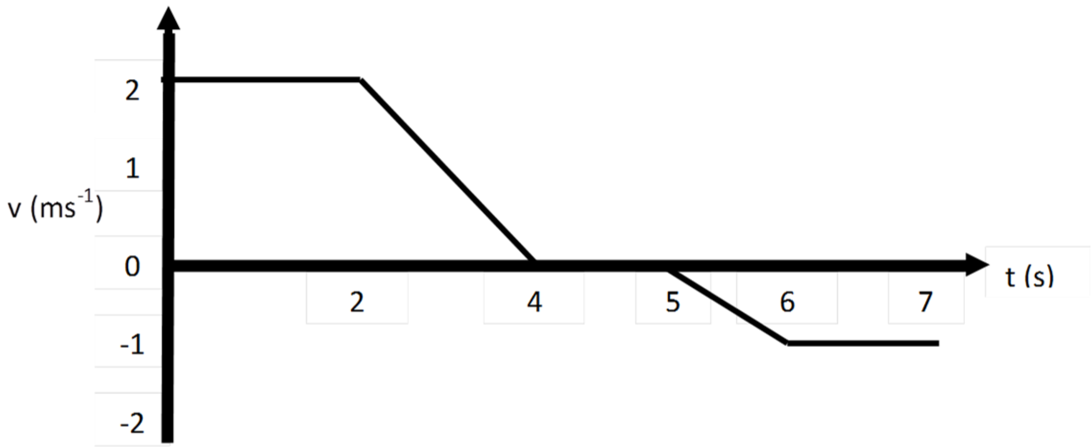
c. A velocity-time graph of the horizontal velocity component of canon ball being fired with an initial horizontal speed of 30 ms^{-1}. **3**

2. This is the acceleration-time graph for a motorbike.



Draw the velocity-time graph for the motorbike over these 8 seconds **5**

3. A car decelerates before a set of traffic lights then comes to rest. The driver then reverses back to the traffic lights.



a. What is the total distance travelled by the car? 2

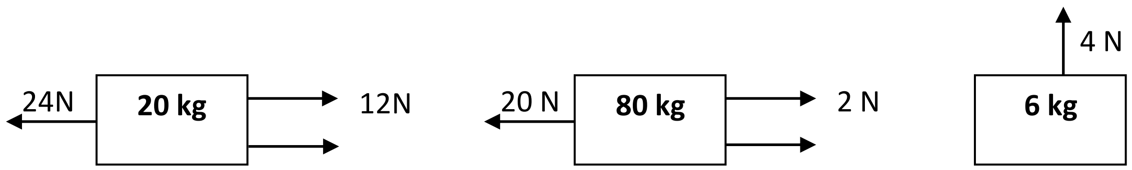
b. What is the displacement of the car? 2

c. How far way were the traffic lights when the car started decelerating? 2

Total 20 marks

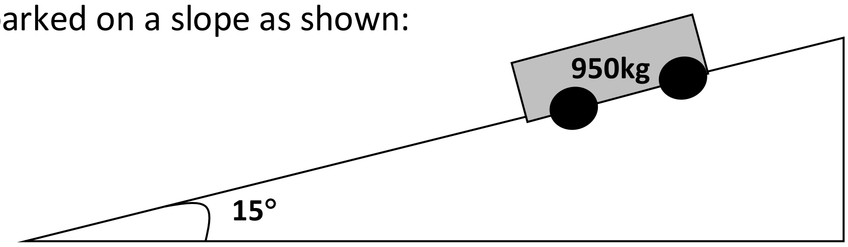
6. Forces

1. For each of these examples, calculate the acceleration of the mass



6

2. A car is parked on a slope as shown:



a. What is the car's weight? **2**
b. What is the component of weight that is parallel to the slope? **2**
c. What is the component of the car's weight that is perpendicular to the slope? **2**
d. The car's handbrake fails. If the frictional force acting on the car is 50N, what will be the car's acceleration as it rolls down the hill **2**

3. A man of mass 70 kg is weighing himself in an elevator.
What will his Newton scales read if:
a. the elevator is accelerating upwards at 1.5 ms^{-2}?
b. the elevator is moving at constant velocity?
c. the elevator is decelerating upwards at 0.8 ms^{-2}? **6**

Total 20 marks

7. Momentum and Impulse

1. A van of mass 1200 kg has a kinetic energy of 70 kJ. What is the momentum of the van? **2**

2. A car of mass 800 kg travelling at 14 ms-1 collides with a car of mass 700 kg that is at rest. The 800 kg car has a velocity of 1 ms-1 in the same direction after the collision.

a. What velocity does the 700 kg car have after the collision? **4**

b. Is the collision elastic or inelastic? **2**

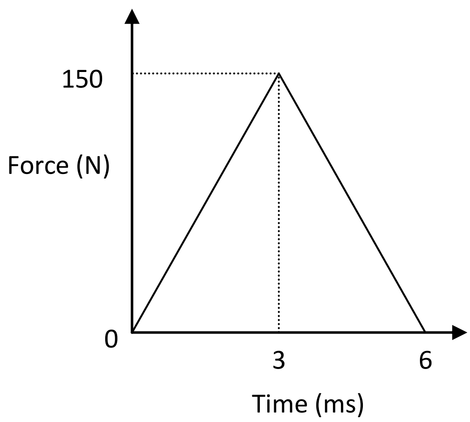
3. A bullet of mass 0.02 kg is fired in to a wooden block of mass 2 kg. If the bullet had a velocity of 60 ms^{-1} as it hit the block, what is the velocity of the wooden block after the collision? (Ignore friction) **4**

4. An ice hockey player hits a 0.2 kg puck with a force of 440 N. The ice hockey stick and puck are in contact for 0.005 s.

a. What impulse does the hockey player exert on the puck? **2**

b. If the puck is originally at rest, what velocity does the puck leave the stick at? **2**

5. This is a force-time graph of a squash player striking a ball of mass 24 g with a racquet



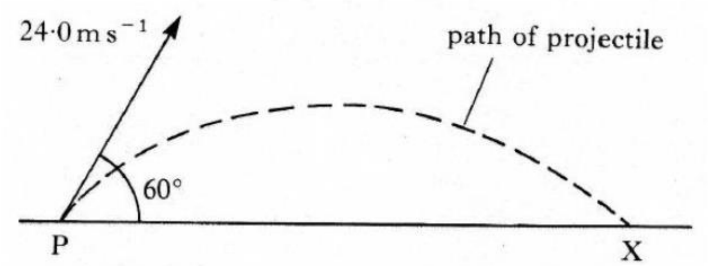
a. What is the impulse exerted on the ball? **2**

b. Calculate the velocity of the ball after it is struck by the racquet **2**

Total 20 marks

8. Gravitation

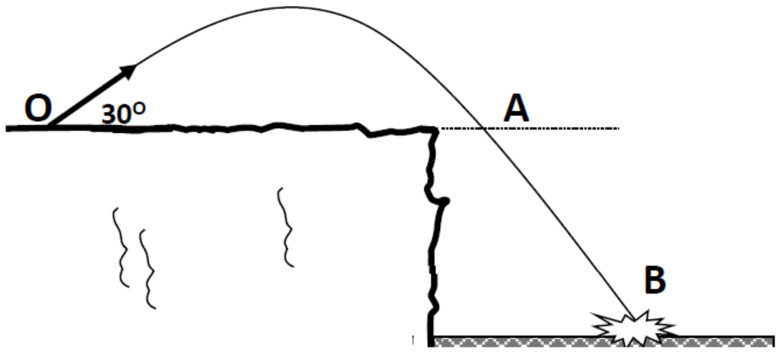
1. During a visit to the moon, the astronaut fires a small experimental projectile across a level surface. The projectile is launched, from point P, at a speed of 24.0 ms^{-1} and at an angle of 60° to the horizontal. The projectile lands 26.0 s later at point X.



a. Calculate the horizontal speed of the projectile at point P. **1**

b. Calculate the horizontal distance P to X **2**

2. A model rocket enthusiast launches a rocket from the edge of a cliff on a calm day.



The flight of the rocket from launch at point O to splashdown in the sea, at B, takes 7 s.

a. Calculate the horizontal and vertical components of velocity **3**

b. The rocket is launched at an angle of 30^{O} to the ground with velocity 40ms^{-1}. Show that the time it takes to go from point O to point A, which is level with the cliff, is 4.1 s. **3**

c. Find the height of the cliff **3**

3. Calculate the gravitational force between two cars parked 0.50 m apart. The mass of each car is 1000 kg. **2**

4. Communication satellites orbit at 36, 000 km.

a. How far is this from the Earth's centre? ($r_E = 6.4 \times 10^6$ m). **3**

b. If the satellite has a mass of 250 kg what is the force of attraction on it from the Earth? ($m_E = 6.0 \times 10^{24}$ kg). **3**

Total 20 marks

9. Special Relativity

1. A scientist in the laboratory measures the time taken for a nuclear reaction to occur in an atom. When the atom is travelling at 8.0×10^{7} m s^{-1} the reaction takes 4.0×10^{-4} s. Calculate the time for the reaction to occur when the atom is at rest. **2**

2. The light beam from a lighthouse sweeps its beam of light around in a circle once every 10 s. To an astronaut on a spacecraft moving towards the Earth, the beam of light completes one complete circle every 14 s. Calculate the speed of the spacecraft relative to the Earth. **2**

3. A pi meson is moving at 0.90 c relative to a magnet. The magnet has a length of 2·00 m when at rest to the Earth. Calculate the length of the magnet in the reference frame of the pi meson. **2**

4. In the year 2050 a spacecraft flies over a base station on the Earth. The spacecraft has a speed of 0.8 c. The length of the moving spacecraft is measured as 160 m by a person on the Earth. The spacecraft later lands and the same person measures the length of the now stationary spacecraft. Calculate the length of the stationary spacecraft. **2**

5. The star Alpha Centauri is 4.2 light years away from the Earth. A spacecraft is sent from the Earth to Alpha Centauri. The distance travelled, as measured by the spacecraft, is 3.6 light years.

a. Calculate the speed of the spacecraft relative to the Earth. **2**

b. Calculate the time taken, in seconds, for the spacecraft to reach Alpha Centauri as measured by an observer on the Earth. **2**

c. Calculate the time taken, in seconds, for the spacecraft to reach Alpha Centauri as measured by a clock on the spacecraft **2**

6. Copy and complete the passage using the wordbank below: **6**

In Einstein's Theory of Special Relativity the laws of physics are the ___ __ for all observers, at rest or moving at constant velocity with respect to each other ie _____ acceleration.
An observer, at rest or moving at constant ___ has their own frame of reference.
In all frames of reference the ____, c, remains the same regardless of whether the source or observer is in motion.
Einstein's principles that the laws of physics and the speed of light are the same for all observers leads to the conclusion that moving clocks run _____(time dilation) and moving objects are ______ (length contraction).

Wordbank:
acceleration, different, fast, lengthened, same, shortened, slow, speed of light, velocity, zero

Total 20 marks

10. The Doppler Effect

1. Copy and complete the passage using the wordbank below: **4**

A moving source emits a sound with frequency fs. When the source is moving towards a stationary observer, the observer hears a __________ frequency f_o. When the source is moving away from a stationary observer, the observer hears a __________ frequency f_o. This is known as the __________ __________.

Wordbank: Doppler, higher, effect, louder, lower, quieter, softer

2. A student is standing on a station platform. A train approaching the station sounds its horn as it passes through the station. The train is travelling at a speed of 25 ms^{-1}. The horn has a frequency of 200 Hz.

a. Calculate the frequency heard as the train is approaching the student **2**

b. Calculate the frequency heard as the train is moving away from the student. **2**

3. A source of sound emits a signal at 600 Hz. This is observed as 640 Hz by a stationary observer as the source approaches. Calculate the speed of the moving source. **2**

4. A battery-operated siren emits a constant note of 2200 Hz. It is rotated in a circle of radius 0.8 m at 3.0 revolutions per second. A stationary observer, standing some distance away, listens to the note made by the siren.

a. Show that the siren has a constant speed of 15.1 ms^{-1} **2**

b. Calculate the minimum frequency heard by the observer **2**

c. Calculate the maximum frequency heard by the observer **2**

5. A girl tries out an experiment to illustrate the Doppler effect by spinning a battery operated siren around her head. The siren emits sound waves with a frequency of 1200 Hz.

a. Describe what would be heard by an observer standing a few metres away **2**

b. Describe and explain what the girl will hear herself **2**

Total 20 marks

11. Redshift and Hubble's Law

1. Light from a distant galaxy is found to contain the spectral lines of hydrogen. The light causing one of these lines has a measured wavelength of 466 nm. When the same line is observed from a hydrogen source on Earth it has a wavelength of 434 nm.

a. Calculate the Doppler shift, z, for this galaxy **2**

b. Calculate the speed at which the galaxy is moving relative to the Earth **2**

c. In which direction, towards or away from the Earth, is the galaxy moving? Explain your answer. **2**

2. The galaxy Corona Borealis is approximately 1 000 million light years away from the Earth.
Calculate the speed at which Corona Borealis is moving away from the Earth. **2**

3. A galaxy is moving away from the Earth at a speed of 3.0×10^{7} m s^{-1}. The frequency of an emission line coming from the galaxy is measured. The light forming the same emission line, from a source on Earth, is observed to have a frequency of 5.00×10^{14} Hz.

a. Show that the wavelength of the light corresponding to the emission line from the source on the Earth is 6.00×10^{-7} m. **2**

b. Find the frequency of the light forming the emission line coming from the galaxy. **2**

4. A distant quasar is moving away from the Earth. Hydrogen lines are observed coming from this quasar. One of these lines is measured to be 20 nm longer than the same line, of wavelength 486 nm from a source on Earth.

a. Calculate the speed at which the quasar is moving away from the Earth. **2**

b. Calculate the approximate distance, in millions of light years, that the quasar is from the Earth. **2**

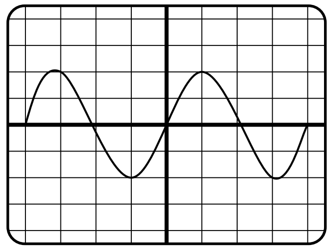
5. Light of wavelength 505 nm forms a line in the spectrum of an element on Earth. The same spectrum from light from a galaxy in Ursa Major shows this line shifted to correspond to light of wavelength 530 nm.

a. Calculate the speed that the galaxy is moving relative to the Earth **2**

b. Calculate the approximate distance, in metres, the galaxy is from the Earth **2**

Total 20 marks

12. AC Signals



1. The oscilloscope shows the potential difference over a bulb attached to an AC power supply

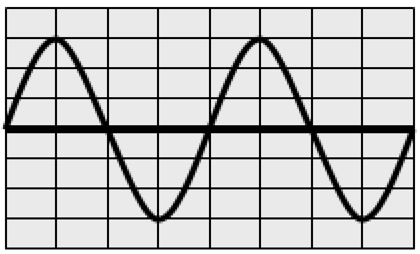
The y-gain is set at 5V / div.
The time base is set at 5ms / div.

a. State the peak potential difference of the trace. **1**
b. Calculate the frequency of the supply. **2**
c. Calculate the rms value of the potential difference **2**

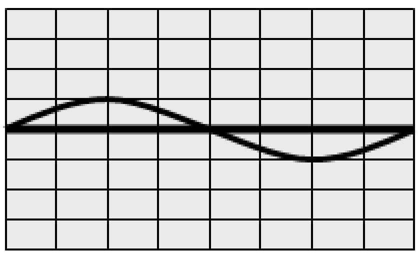
2. The root mean square voltage produced by a low voltage power supply is 10 V.
a. Calculate the peak voltage of the supply **2**
b. An oscilloscope, with its time-base switched off, is connected across the supply. The Y-gain of the oscilloscope is set to 5 V cm^{-1}. Describe the trace seen on the oscilloscope screen M **2**

3. An a.c. signal of frequency 20 Hz is connected to an oscilloscope. The time-base switch on the oscilloscope is set at 0.01 s cm^{-1}. Calculate the distance between the neighbouring peaks of this waveform when viewed on the screen. **2**

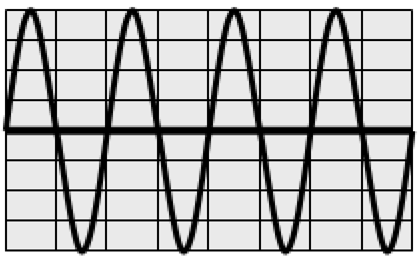
4. For each of the oscilloscope traces find: **9**
a. The peak voltage, b. The rms voltage, c. the frequency of the wave



Y – gain = 2V / div
timebase = 4ms / div



Y – gain = 8V / div
timebase = 10ms / div



Y – gain = 0.5V / div
timebase = 2ms / div

Total 20 marks

13. Emf and Internal Resistance

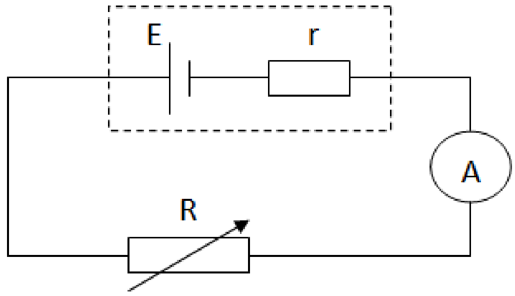
1. Explain what is meant by

a. Electromotive force (e.m.f.)
b. Load resistor
c. Internal resistance
d. Terminal potential difference (t.p.d.)
e. Lost volts
f. Short circuit current **6**

2. In the circuit below, the reading on the voltmeter is 5 V when switch **S** is open and 3 V when it is closed.

a. What is the emf of the cell? **1**
b. Calculate the current flowing in the circuit when the switch is closed **2**
c. What is the internal resistance of the cell? **2**

3. Look at the circuit diagram:



a. Sketch a graph to show how the tpd changes as current increases in the circuit. **3**
b. How can the graph be used to calculate the internal resistance of the supply? **1**
c. How can your graph be used to calculate the emf of the power supply? **1**

4. A battery of e.m.f. 1.56 V is connected to a resistor of value 16 Ω and it's terminal potential difference falls to 1.28 V

a. Calculate the lost volts **2**
b. Calculate the internal resistance of the cell **2**

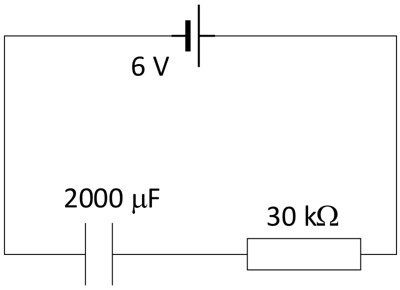
Total 20 marks

14. Capacitors

1. Calculate the charge stored in a:

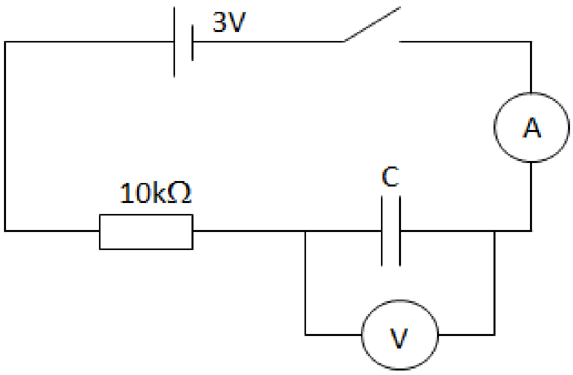
a. 2000 µF capacitor at 10 V
b. 2 mF capacitor at 3 V
c. 500 µF capacitor at 9 V
d. 30 µF capacitor at 12 V **4**

2. A physics student set up a circuit as shown.



a. Calculate the charge stored by the capacitor. **2**
b. Calculate the energy stored by the capacitor **2**
c. The 6 V battery is replaced with a 12 V battery.
Calculate the energy stored by the capacitor now **2**

3. The capacitor in this unit is initially uncharged



a. Find the value of the initial current when the switch is closed. **2**
b. What is the current when the capacitor is fully charged? **2**
c. Find the voltage across the capacitor when it is fully charged? **2**
d. During charging, the voltmeter shows a reading of 1.2 V. **2**
What is the charging current flowing in the circuit at that instant?
e. Draw current-time and voltage-time graphs to show how they vary as the capacitor is being charged. **2**

Total 20 marks

15. Conductor, Semiconductors and Insulators

1. Describe what is meant by the following terms and give **two** examples for each one:

a. A conductor **3**

b. A semiconductor **3**

c. An insulator **3**

2. The conductivity of a substance can be increased by "doping".

a. Explain what is meant by the "conductivity" of a material **1**

b. Explain (using an example) what is meant by "doping" a semiconductor **2**

c. Why does "doping" decrease the resistance of a semiconductor? **2**

3. A sample of pure germanium (four electrons in the outer shell) is doped with phosphorus (five electrons in the outer shell).

a. What kind of semiconductor is formed? **1**

b. Explain your answer. **1**

4. Why does a sample of n-type semiconductor still have a neural overall charge? **2**

5. Describe the movement of the majority charge carriers when a current flows in:

a. an n-type semiconductor material **1**

b. a p-type semiconductor material **1**

Total 20 marks

16. p-n junctions

1. A p-n junction diode is connected across a d.c. supply as shown.

a. Is the diode connected in forward or reverse bias? **1**
b. Describe the movement of the majority charge carriers across the p-n junction. **2**
c. What kind of charge is the only one that actually moves across the junction? **2**

2. When positive and negative charge carriers recombine at the junction of ordinary diodes and LEDs, quanta of radiation are emitted from the junction.
a. Does the junction have to forward or reverse biased for radiation to be emitted? **1**
b. What form does this emitted energy take when emitted by:
   i. an LED **1**
   ii. an ordinary junction diode **1**

3. LEDs can be used in place of a filament lamp
a. Give two advantages of an LED over an ordinary filament bulb **2**
b. An LED is to be operated from a 6 V d.c. power supply but has an operating pd of 1.8 V and 20 mA.
   i. Draw a diagram of the circuit including a protective resistor, which allows the led to work at this voltage **2**
   ii. Calculate the value of the resistor needed to allow the LED to operate **2**

4. The Following LEDs are connected to a 6 V supply
Find the size of the protective resistor needed to protect them:
a. LED 1 has an operating value of 1.2 V at 20 mA **2**
b. LED 2 has an operating value of 1.0 V at 20 mA **2**
c. LED 3 has an operating value of 1.8 V at 10 mA **2**

Total 20 marks

17. The Standard Model

1. Copy and complete the table, placing the following fermions into the correct column. **10**

Fermions:	bottom, charm, down, electron, strange, tau, tau, neutrino, top, up electron neutrino, muon, muon neutrino

Quarks	Leptons

2. Consider Leptons and Hadrons.

a. State the difference between a lepton and a hadron in terms of the type of force experienced by each particle. **2**

b. Give one example of a hadron **1**

3. Information on the sign and charge relative to proton charge of six quarks (and their antiquarks) is shown in the table below.

Quark name	*Charge relative to size of proton charge*	*Antiquark name*	*Charge relative to size of proton charge*
up	+2/3	antiup	–2/3
charm	+2/3	anticharm	–2/3
top	+2/3	antitop	–2/3
down	–1/3	antidown	+1/3
strange	–1/3	antistrange	+1/3
bottom	–1/3	antibottom	+1/3

a. Calculate the charge of the following combinations of quarks:

i. two up quarks and one down quark
ii. one up quark and two down quarks
iii. two antiup quarks and one antidown quark
iv. one antiup quark and two antidown quarks 4

b. Name the force which holds the quarks together in protons and neutrons. **1**

4. Describe two advantages of a PET scan over an x-ray **2**

Total 20 marks

18. Forces on Charged Particles

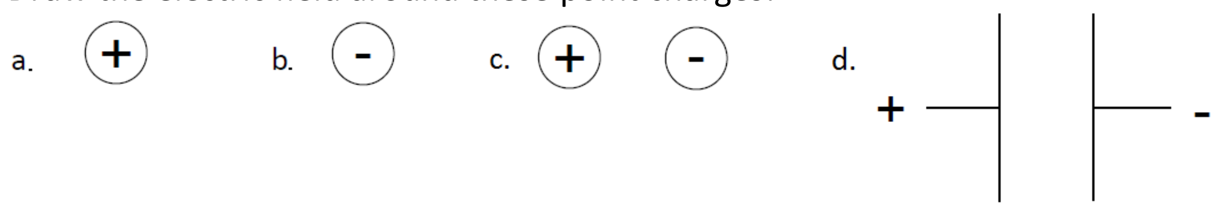
1. What is the definition of 1 Volt? **1**

2. Calculate the charge when:

a. A current of 20 A flows for 6 seconds? **2**

b. A current of 50mA flows for 10 minutes? **2**

3. Draw the electric field around these point charges: **8**

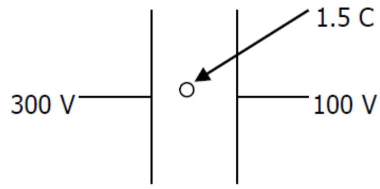


4. The current in a circuit due to electrons crossing between plates in an evacuated tube is 10mA. [$Q_e = 1.6 \times 10^{-19}$ C]. How many electrons cross the gap in five seconds? **2**

5. How much energy is required to move a charge of 2 mC through a pd of 100 V? **2**

6. Calculate the potential difference if it takes 100 J of energy to move a 0.2 C charge. **2**

7. Look at the following diagram:



a. What is the potential difference between the two plates? **1**

b. Calculate the work done in moving the charged particle across the electric field. **2**

Total 20 marks

19. Particle Accelerators

In the following questions, when required, use the following data:

Charge on electron = $-1{\cdot}60 \times 10^{-19}$ C　　Mass of electron = $9{\cdot}11 \times 10^{-31}$ kg

Charge on proton = $1{\cdot}60 \times 10^{-19}$ C　　Mass of proton = $1{\cdot}67 \times 10^{-27}$ kg

1. In an evacuated tube, an electron initially at rest is accelerated through a p.d. of 500 V.

a. Calculate, in joules, the amount of work done in accelerating the electron. **2**

b. How much kinetic energy has the electron gained? **1**

c. Calculate the final speed of the electron. **2**

2. In an electron gun, electrons in an evacuated tube are accelerated from rest through a potential difference of 250 V.

a. Calculate the energy gained by an electron. **2**

b. Calculate the final speed of the electron **2**

3. The power output of an oscilloscope (cathode-ray tube) is estimated to be 30 W. The potential difference between the cathode and the anode in the evacuated tube is 15 kV.

a. Calculate the number of electrons striking the screen per second **3**

b. Calculate the speed of an electron just before it strikes the screen, assuming that it starts from rest and that its mass remains constant. **3**

4. Describe the basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles. **5**

Total 20 marks

20. Fission & Fusion

1. In nuclear fission, a large nucleus splits into two nuclei of smaller mass with the release of several neutrons and energy:

a. Give two reasons why the mass of the two nuclei does not equal the mass of the original nuclei **2**

b. Explain why the above reaction could be part of a chain reaction **3**

2. A Uranium atom decays as shown:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{98}_{42}Mo + ^{136}_{54}Xe + 2\,^{1}_{0}n + 4\,^{0}_{-1}e$$

Particle	**Mass (kg)**
^{235}U	3.9×10^{-25}
^{98}Mo	1.63×10^{-25}
^{136}Xe	2.25×10^{-25}
Neutron	1.67×10^{-27}
Electron	9.11×10^{-31}

a. Name the type of reaction **1**

b. Find the energy released by this reaction **4**

3. A Uranium atom decays as shown:

$$^{239}_{94}Pu + ^{1}_{0}n \Rightarrow ^{137}_{X}Te + ^{Y}_{42}Mo + 3\,^{1}_{0}n$$

Particle	Mass (u)
^{239}Pu	239.0512
^{137}Te	137.0000
^{Y}Mo	99.9066
n	1.0087
where 1 u = 1.66 x 10-27 kg	

a. Calculate the numbers X and Y. **2**

b. Find the energy released by this reaction **4**

4. A radioisotope has a half life of 180 s.
Initially a sample has an activity of 9×10^{14} Bq

a. What will the activity of the sample be after 15 minutes? **2**

b. When will the activity be less than 20 Bq **2**

Total 20 marks

21. Photoelectric Effect

1. When introducing the photoelectric effect a Physics teacher writes:

'One of the important factors affecting photoelectric emission from a metal is the threshold frequency for the metal.'

Explain the meaning of the terms:
a. Photoelectric effect
b. Threshold frequency **2**

2. Red light has a wavelength of $6{\cdot}44 \times 10^{-7}$ m.
Calculate the energy of one photon of this light. **2**

3. The work function for a particular metal is stated as 5×10^{-19} J.
a. What is the minimum frequency of electromagnetic radiation required to produce the photoelectric effect with this metal? **2**
b. If radiation of frequency 8.45×10^{-19} Hz is incident on the same metal calculate the maximum kinetic energy gained by each photoelectron. **2**

4. For a certain metal, the energy required to eject an electron from an atom is 3×10^{-19} J.
a. What is the minimum frequency of electromagnetic radiation required to produce the photoelectric effect with this metal? **2**
b. The metal is illuminated with blue light that has a wavelength of 400 nm. **2**
Show by calculation that this will cause the photoelectric effect to occur.
c. Calculate the kinetic energy that the ejected electrons will have when the metal is illuminated with this light. **2**

5. For a certain metal, the energy required to eject an electron is $3{\cdot}30 \times 10^{-19}$ J
a. Calculate the minimum frequency of radiation required to emit a photoelectron from the metal. **2**
b. Explain whether or not photoemission would take place using radiation of:
i. frequency 4×10^{14} Hz **2**
ii. wavelength 5×10^{-7} m. **2**

Total 20 marks

22. Interference

1. An experiment is set up to investigate interference effects and a pattern of dark and bright fringes is produced. Explain, in terms of waves, how the patterns of bright and dark fringes are produced. **2**

2. A laser is aimed at a double slit with a 2.5×10^{-4} m separation

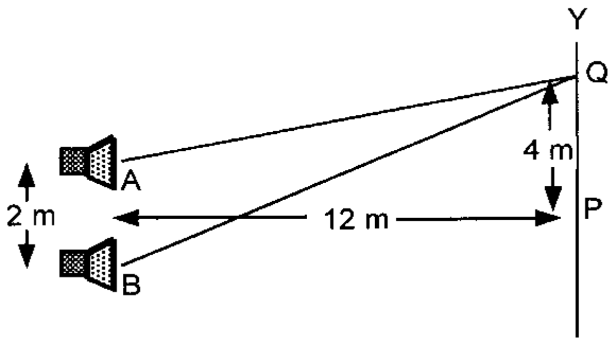
a. Calculate the angle θ for the first maximum **2**

b. Calculate the angle θ for the second maximum **2**

c. Calculate the frequency of the laser light **2**

d. State two ways the distance between the maxima could be increased **2**

3. In an experiment on interference of sound, two loudspeakers A and B are connected in such a way that they emit coherent sound waves.



The loudspeakers are placed 2 m apart. As a girl walks from X to Y she hears a point of maximum loudness at point P and the next maximum of loudness at point Q.

a. Calculate the distances AQ and BQ. **2**

b. Calculate the wavelength of the sound. **2**

c. Calculate the frequency of the sound. (speed of sound in air is 330 ms^{-1}) **2**

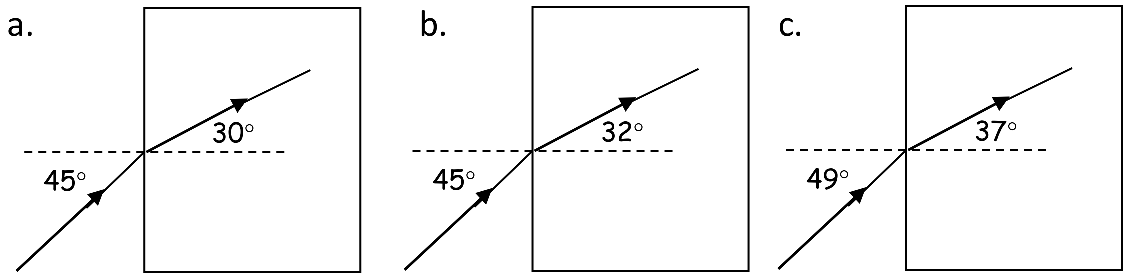
4. A laser emits light with a wavelength of 538 nm. If it strikes a diffraction grating which has a line spacing 100 times larger than the wavelength, calculate the angle which separates the central and first order maxima. **2**

5. A grating or a prism can be used to produce spectra from a source of white light. Give two differences between the spectra obtained using the grating and the prism. Diagrams may be used to illustrate your answer. **2**

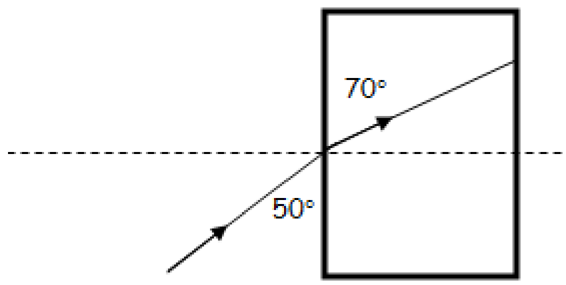
Total 20 marks

23. Refraction

1. Calculate the refractive index for each of the blocks below: **6**

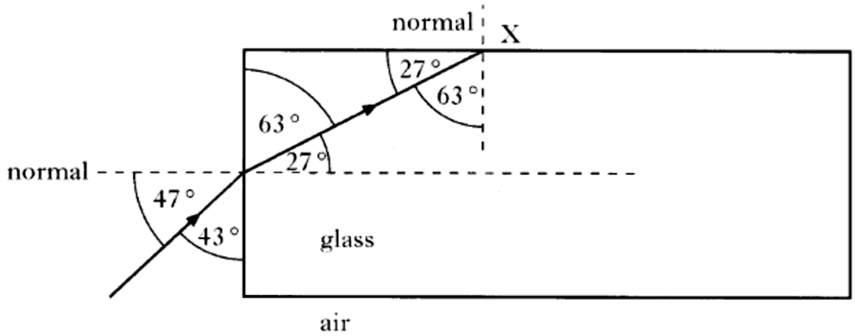


2. A ray of red light (λ = 600 nm) enters a glass block as shown



a. What is the refractive index of the glass? **2**
b. Calculate the critical angle of the glass. **2**
c. Calculate the speed of light in the glass. **2**
d. Calculate the wave of light inside the glass **2**

3. A ray of monochromatic light passes from air into a glass block as shown:



The loudspeakers are placed 2 m apart. As a girl walks from X to Y she hears a point of maximum loudness at point P and the next maximum of loudness at point Q.

a. Find the refractive index of the glass. **2**
b. Calculate the critical angle of the glass. **2**
c. Sketch a diagram of the ray passing through the block and complete it to show how the ray of light continues at point X **2**

Total 20 marks

22. Spectra

1. A solar cell (10 cm x 8 cm) receives 2.4 J of light each second. What is the intensity of the light landing on the solar cell? **2**

2. The intensity of sunlight at the surface of the Earth is approximately 1500 Wm^{-2}. If the Earth is 150 x 10^9 m from the sun, calculate the intensity of sunlight on each of the following planets

a. Mercury (5.8 x 10^{10} m from the sun) **2**

b. Saturn (1.4 x 10^{12} m from the sun) **2**

c. Pluto (5.9 x 10^{12} m from the sun **2**

3. A laser used in a CD player emits monochromatic light of wavelength 840 nm..

a. When the light passes through a grating only one bright line is seen in the spectrum. Explain why only one line appears in the emission spectrum of the laser. **2**

b. Calculate the difference in energy between the two energy levels that produce photons at this wavelength **2**

4. What is meant by:

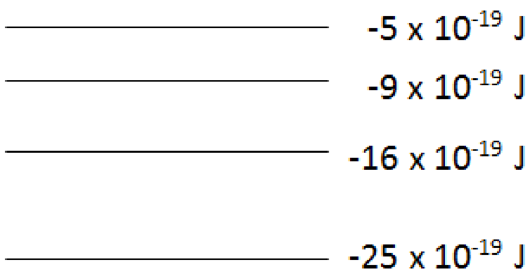
a. the ground state of an electron

b. an excited state of an electron

c. the ionisation level of an electron

d. electron transition **4**

5. The following diagram represents the atomic structure



a. How many possible transitions are there? **1**

b. Calculate the maximum frequency of light absorbed by this atom **2**

c. Which part of the EM spectrum does the light emitted belong to? **1**

Total 20 marks