50 Higher Physics Revision Exercises

1-10 Mechanics and Properties of Matter

11-20 Mechanics and Properties of Matter
plus Electricity and Electronics

21-50 Mechanics and Properties of Matter
plus Electricity and Electronics
plus Radiation and Matter

Exercise 1

1. A car starts from rest and reaches a speed of 40 ms^{-1} in a time of 8 seconds. Calculate its average **acceleration**.

2. What is the missing term in the 'equation of motion': **s = ut +** ____ **?**

3. In the 'equation of motion': **v = u + at**, in what **unit** is the term **'at'** measured?

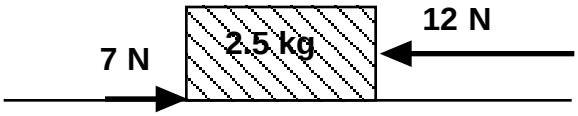
4. Calculate the **kinetic energy** of a mass of 2 kg moving with a speed of 3 ms^{-1}.

5. Find the **size** of the **resultant** force of two forces of 10 N acting at the same point where the **angle** between them is (a) 0^o, (b) 30^o and (c) 120^o.

6. How **far** would a person run in 15 seconds at an **average** speed of 7 ms^{-1}?

7. Which of the following quantities is/are **vectors**: distance, speed, displacement, mass, weight, velocity, momentum, energy, work and force? What **name** is given to all the **remaining** quantities?

8. A mass of 2·5 kg is acted on by a 12 N force, with 7 N of **friction** acting in the opposite direction. Calculate the **unbalanced** force on the mass and the **magnitude** of its acceleration.



9. How much **work** is done by a force of 6 newtons when it moves a total distance of 7 metres in its **own** direction?

10. A car accelerates uniformly from 10 ms^{-1} to 24 ms^{-1}. What is its **average** speed?

11. (a) Can an object have **mass** but no **weight**? If so, give an example.
    (b) Can an object have **weight** but no **mass**? If so, give an example.

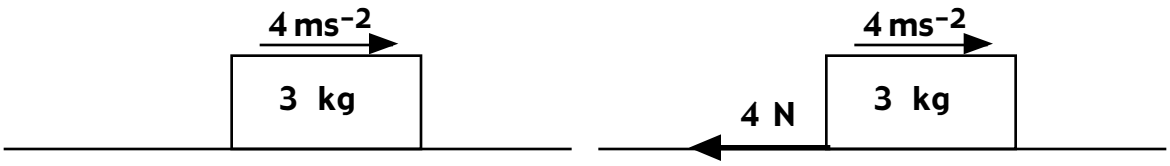
12. Give an example of an object moving at a **constant speed** while **accelerating** at the same time. (Hint: remember that acceleration describes the change of an object's **velocity**).

Exercise 2

1. How **long** would a car take to travel 2·4 km at an average speed of 30 ms^{-1}?

2. Calculate the **change of speed** experienced by a train which accelerates for 9 seconds at a rate of 2·5 ms^{-2} in a straight line.

3. What **unbalanced** force acts on a mass of 3 kg which accelerates at 4 ms^{-2} on a horizontal surface if
   (a) there is **no** friction and (b) if there **is** friction of 4 N?



4. A stone is thrown **horizontally** from the top of an 80 m high cliff at 30 ms^{-1}. Find **how long** it takes to fall to the sea below and its **velocity** (size and direction) as it enters the water. ('g' = 10 ms^{-2})

5. An astronaut weighs 735 N on Earth where 'g' is 9·8 Nkg^{-1}. What is her **mass** (a) on the Earth and (b) on the Moon where 'g' is 1·7 Nkg^{-1}?

6. For a uniformly accelerated motion, what is calculated by halving the **sum** of the initial velocity '**u**' and the velocity '**v**' after time '**t**'?

7. A car starts at rest and accelerates uniformly at 3 ms^{-2} for 4 seconds in a straight line. Find its **speed** after 4 seconds and how **far** it has travelled.

8. A boy throws a tennis ball so that it leaves his hand at 25 ms^{-1} at an angle of 40^{o} above the horizontal. Find the **horizontal** component of the ball's velocity as it leaves the boy's hand.

9. At what **speed** is a 250 g stone moving if its kinetic energy is 3·5 joules?

10. How much gravitational **potential energy** does a 60 kg boy lose when he walks down a flight of stairs which is 4·5 m high?

11. A weight lifter raises a barbell of mass 20 kg and, in so doing, does 490 J of work. Through what **height** does he lift the barbell?

12. An electric motor raises a container of mass 120 kg on the Moon through a height of 4 m in a time of 6 s. Calculate the **output power** of the motor.
    (g = 1·7 Nkg^{-1}).

Exercise 3

1. Which **quantity** is represented by the term '$\frac{1}{2}at^2$' and in which **unit** could it be measured?

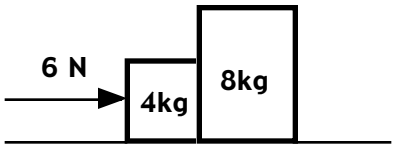
2. What is the size of the **friction** force if a 3 kg mass accelerates along a horizontal surface at 2·5 ms^{-2} when acted on by a pulling force of 10 N?

3. A boy does 72 J of work in dragging a 30 kg mass along a floor for 3 metres. What **force** does he apply? (Assume the force is **parallel** to the floor).

4. A boat motoring due north through the **water** at 8 ms^{-1} is deflected by a current of 3 ms^{-1} which is running due east. Find the **actual** speed and direction of the boat relative to the **sea bed**.

5. A machine raises a mass of 250 kg through a height of 3 m in a time of 5 s. Find the **output** power of the machine. (Take 'g' as 10 Nkg^{-1}).

6. Two blocks are pushed along a **frictionless** surface, as shown, by a force of 6N. Calculate (a) the **acceleration** of the blocks, (b) the **unbalanced force** on the **4 kg** block and (c) the **force** exerted by the 8 kg block on the 4 kg block.



7. A car moving at 8 ms^{-1} accelerates at 4 ms^{-2} for 5 s in a straight line. Find the **extra distance** travelled by the car from the **start** of the acceleration.

8. How does the **slope** (or gradient) of a velocity-time graph for a moving object depend on the **size** of the object's acceleration?

9. Sketch the **shape** of a velocity-time graph for an object moving with a **decreasing** acceleration, starting from rest.

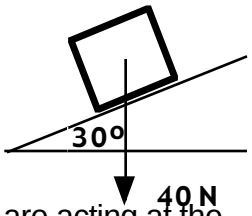
10. What is the **mass** of an object travelling at 8 ms^{-1} which has 96 J of kinetic energy?

11. What is the **unbalanced** force acting on a car of mass 1800 kg being driven along a flat, horizontal road if the forward engine force is 5000 newtons and frictional forces total 500 newtons? What is its **acceleration?**

12. What is the **final** velocity of an object which accelerates in a straight line over a distance of 13 m at a steady rate of 6 ms^{-2} from a starting velocity of 10 ms^{-1}?

Exercise 4

1. A block of wood of weight 40 N rests on a 30º slope. What is the component of its weight **parallel** to the slope?



2. Find the **resultant** force of two forces, 2 N and 3 N, which are acting at the same point at an angle of 40º to each other.

3. What is the **gravitational field strength** at the surface of a planet where an 80 kg woman weighs 520 N?

4. What is the **size** of the momentum of a 3000 kg car moving at 20 ms^{-1}?

5. A ball, rolling along a flat, horizontal surface with momentum +7 $kgms^{-1}$ strikes a rigid wall and bounces so that it moves back in the **opposite** direction with momentum of -5 $kgms^{-1}$. Calculate the **change** in momentum of the ball.

6. How much gravitational potential energy is **lost** by a rock of mass 3 kg falling to the foot of a 250 m cliff on the Moon where 'g' is 1·7 Nkg^{-1}?

7. In the equation '**v = u + at**', what do the terms '**u**' and '**at**' represent?

8. In a rocket engine, what is the **reaction** to the force exerted on the exhaust gases by the rocket?

9. A man of weight 800 N is standing on scales in a lift moving at a **constant velocity** of 2 ms^{-1} between floors. What do the scales read if the lift is moving (a) **up** (b) **down**? (Take 'g' = 10 Nkg^{-1}).

10. Taking 'g' as 10 Nkg^{-1}, what **thrust** would be needed to accelerate a rocket of mass 500 x 10^3 kg vertically upwards at 2·5 ms^{-2}?

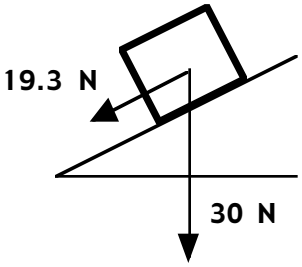
11. A boy quotes the **absolute** error in a balance reading of 3·4 newtons as being 'plus or minus 0·2 newtons'. Calculate the **percentage** error in the reading.

12. Sketch the **shape** of a velocity-time graph for the motion of an object which starts at rest and has an **increasing** acceleration.

Exercise 5

1. Which **quantities** are calculated by the **areas** under (a) a speed-time graph and (b) a velocity-time graph?

2. What **angle** does a slope make with the horizontal if a 30 N weight has a component of 19·3 N **parallel** to the slope?



3. What time has elapsed if an object, accelerating uniformly at 4 ms^{-2} from 20 ms^{-1} in a straight line, travels an ***extra*** distance of 150 m?

4. In what **unit** might the term '$\sqrt{2as}$' be expressed?

5. The **horizontal** component of a projectile's velocity is 15 ms^{-1} at launch. What would its **horizontal** displacement be 12 seconds after launch?

6. A stone of mass 3 kg falls vertically from a cliff and reaches a speed of 40 ms^{-1} **just before** hitting the ground. What was its potential energy **before** it fell, assuming that it fell from rest?

7. Sketch the velocity-time graph for the first **three** bounces of a ball dropped vertically from rest, assuming that **some** mechanical energy is lost during each bounce.

8. What is the acceleration of a ball, thrown vertically upwards, at the instant it reaches its **highest** point?

9. A 70 kg man is in a lift accelerating upwards between floors at 2·5 ms^{-2}. How **heavy** does he ***feel*** and what is his ***actual*** **weight?**

10. A 250 tonne rocket accelerates vertically upwards from the launchpad on Earth at 1·5 ms^{-2}. Taking 'g' as 10 Nkg^{-1}, what **thrust** is developed by the rocket's engines? (1 tonne = 1000 kg).

11. A bicycle is being ridden along a horizontal road by a "pedal" force of 400 N. Its speed is **constant** at 12 ms^{-1}. What is the total value of the **frictional** forces acting on the bike and its rider?

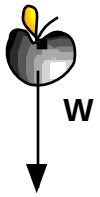
12. Sketch the likely shape of the **speed-time** graph for the motion of a stone released from rest from the surface of a deep loch.

Exercise 6

1. What is the **size** of the momentum of a 600 gram stone moving at 20 ms^{-1}?

2. Define an **elastic** collision between two objects.

3. What is the **reaction** force to the **weight** of an apple?



4. How much **work** is done by a man on a bag of shopping of weight 300 newtons if he carries it a **distance** of 200 metres at a **constant** height?

5. A 20 g bullet travelling at 400 ms^{-1} embeds itself in a sandbag. Calculate the **impulse** of the bullet's force on the sandbag.

6. Complete this statement: **impulse = ------ of --------.**

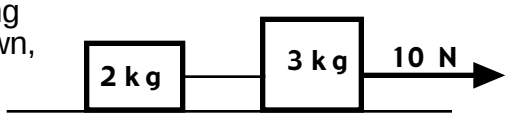
7. Which, if any, of the following quantities is/are **vectors**: heat, kinetic energy, potential energy, work, weight, time, momentum and speed?

8. What was the **initial** velocity of an object, accelerating uniformly in a straight line at 12·5 ms^{-2}, which has a displacement of 20 m in reaching a velocity of 30 ms^{-1}?

9. Find the **average** speed of a car which decelerates at 4 ms^{-2} for 3 s from an initial speed of 20 ms^{-1}.

10. An arrow is fired from a bow at an angle of 60^{o} to the horizontal and at a speed of 120 ms^{-1}. Find the initial vertical and horizontal **components** of the arrow's velocity.

11. Two masses, joined by a light cord are being pulled along a **frictionless** surface, as shown, by a **10 N** force. Calculate:
(a) the **acceleration** of the masses,
(b) the **unbalanced force** on the **3 kg** mass,
(c) the **tension** in the cord.



12. A boy measures the weight of 6 'identical' masses with the **same** balance and notes the following results, in newtons:

12·2, 12·5, 12·1, 12·6, 12·6, 12·7.

Calculate the **best estimate** of the weight of a mass and its **random error**.

Exercise 7

1. A stone is thrown vertically upwards at 40 ms^{-1}. How **long** does it take to reach its **highest** point? ('g' = 10 ms^{-2}). **Where** is it after 8 seconds?

2. A train travelling in a straight line at 100 ms^{-1} decelerates to rest at a **uniform** rate and travels an **extra** distance of 1250 m.
   Find the size of the train's **deceleration**.

3. A 100 g ball is moved from rest with a kick of **impulse** 3 Ns.
   At what **speed** does the ball move off?

4. A 90 kg man is standing on a set of scales in a moving lift. At an instant when the lift is moving **down** and getting faster at the rate of 3 metres per second per second, what would the scales **read**? (Take 'g' as 10 Nkg^{-1}).

5. A man pulls a mass of 50 kg with a rope along a **frictionless** horizontal surface from rest to a velocity of 10 ms^{-1} in 20 seconds.
   Calculate the **horizontal** component of the **force** exerted by the man.

6. On the Moon, a rock would free fall with an acceleration of 1·7 ms^{-2} downwards. If a rock was thrown upwards, what would its **acceleration** be **on the way up**?

7. A 5 kg mass slides down a frictionless slope with an acceleration of 6·5 ms^{-2}. What **angle** does the slope make with the horizontal? ('g' = 10 Nkg^{-1}).

8. What is the **reaction** to the force of a horse pulling a cart along a farm track?

9. A small spacecraft of mass 2·3 t is designed to lift off from the Moon's surface at 3 ms^{-2} vertically upwards. Calculate the **thrust** exerted by the spacecraft's rocket engine. ('g' = 1·7 Nkg^{-1}; 1 t = 1000 kg).

10. An astronaut has a weight of 833 N on the surface of the Earth where the gravitational field strength is 9·8 Nkg^{-1}. What would be the astronaut's **weight** and **mass** on the surface of another planet where the gravitational field strength is 4 Nkg^{-1}?

11. Sketch a graph to show the relationship between **pressure** and **depth** in a liquid of uniform density.

12. A 3 kg trolley moving at 40 cms^{-1} collides with and **joins** to a stationary trolley of mass 2 kg on a horizontal, frictionless surface. Calculate the speed at which the trolleys move after the collision and the loss of kinetic energy.

Exercise 8

1. When a 20 000 tonne liner is floating at rest in the sea, what is the size and direction of the **buoyancy force** acting on it? (1 tonne = 1000 kg),

2. A quantity of metal has the following measurements:
   mass = 88·4 g; volume = 6·5 cm^3.
   Calculate its **density** in (a) gcm^{-3} and (b) kgm^{-3}. **Identify** the metal.

3. The pressure at a depth of 50 cm in water is 4900 pascals above atmospheric pressure. What would it be at the ***same depth*** in a liquid with a density 90% that of water?

4. Sketch a speed-time graph for an object which moves with **decreasing** deceleration from a starting speed '**u**' to rest in '**t**' seconds.

5. How **long** would an object take to travel 210 m from an initial velocity of 20 ms^{-1} with a uniform acceleration of 5 ms^{-2}?

6. What **unbalanced** force is acting on a car of mass 2000 kg being driven up a constant gradient of 20^o at a **steady** velocity of 15 ms^{-1}?

7. A 4 kg block of wood is at **rest** on a slope of 30^o. If 'g' = 9.8 Nkg^{-1}, find
   (a) the force of **friction** between the block and the slope and
   (b) the **normal reaction** of the slope on the block.

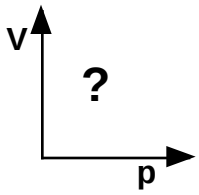
8. A ball of mass 150 g travelling horizontally at 30 ms^{-1} is struck by a racquet so that it is sent back in the **opposite** direction at 50 ms^{-1}. If the time of contact between the racquet and the ball is 40 ms, find the **average** force exerted on the ball.

9. A 20 g bullet becomes embedded in a 2 kg block of wood hanging from a string. The block swings up to a maximum **height** of 1.25 m.
   Find the speed of the bullet before it hit the block.

10. Change the following temperatures into **kelvin**: 0^oC; -20^oC; 100^oC; -273^oC.

11. A gas trapped in a **rigid** container is at a pressure of $1{\cdot}2 \times 10^5$ Pa when its temperature is 20^oC. Calculate its **pressure** at 80^oC.

12. Sketch a **graph** to show how the **volume** of a fixed mass of gas at a constant temperature would vary with **pressure**.



Exercise 9

1. Two trolleys at rest on a horizontal surface **explode** apart so that one of them, with a mass of 1000 g, moves off at 30 cms^{-1}. The other's speed is 45 cms^{-1}. What is its **mass**?

2. A 2 kg trolley, moving at 40 cms^{-1}, collides with and **sticks** to a 3 kg trolley at rest on a horizontal surface. Calculate the **kinetic energy** lost during the collision.

3. Sketch a possible speed-time graph for a sky diver from the instant of jumping out of a stationary balloon till ***just before*** the parachute is opened when he is travelling with a **terminal velocity** of 60 ms^{-1}.

4. In Q3, if the parachutist's mass is 75 kg, calculate the force of air resistance acting on him **just before** he opens his parachute. ('g' = 10 Nkg^{-1}).

5. A 1500 kg car accelerates at 1·5 ms^{-2} along a horizontal road. If the frictional forces acting against the car's motion total 1000 N, what **driving** force is exerted on the road by the car's wheels?

6. If a syringe contains 100 cm^3 of a gas at 20^oC and its pressure is 1 atmosphere, calculate the **volume** occupied by the gas if the pressure is increased to 1·5 atmospheres and the temperature becomes 240^oC.

7. What is the **greatest** height a ball could reach if kicked at a speed of 70 ms^{-1} at the surface of the Moon where the gravitational field strength is 1·7 Nkg^{-1}?

8. A trolley of mass 3·5 kg runs down a 'frictionless' slope with an acceleration of 2·4 ms^{-2}. The trolley is now loaded with an **additional** mass of 2.5 kg. What would its acceleration be down the slope now?

9. A 2 kg trolley accelerates down a slope at 2·5 ms^{-2}. If there is 5·3 newtons of friction acting against the trolley's motion, calculate the **angle** of the slope (to the nearest degree).

10. A shell is fired from a cannon at 40^o to the horizontal and at 200 ms^{-1}. What is (a) its horizontal velocity and (b) its vertical velocity **one second** later? (Take g = 10 Nkg^{-1}).

11. What **unbalanced** force acts on a 40 kg girl travelling downwards in a lift which is increasing its speed at the rate of 2·5 ms^{-2}?

12. 1 cm^3 of water is boiled into steam. What would the approximate **volume** of the steam be if the average water molecule separation increased from 1 to 9 molecular diameters?

Exercise 10

1. A train, travelling at a steady velocity, starts to **decelerate** at a rate of 4 ms^{-2}. After 3 seconds it has travelled a **further** displacement of 138 m in a straight line. Find the **velocity** from which it decelerated.

2. A mass of 2·5 kg is released from rest on a slope of 34^o and experiences a friction force of 3·7 N up the slope. Taking 'g' as 9·8 Nkg^{-1}, calculate the **acceleration** of the block down the slope.

3. In measuring the unbalanced force acting on a trolley, the following measurements were made:
   mass = (1·2 $^+$/- 0·2) kg; **acceleration = (3·4$^+$/- 0·1) ms^{-2}**.
   Calculate the **best estimate** of the force and the **uncertainty** in it.

4. What **volume** would 30 g of mercury occupy if its **density** is 13·6 gcm^{-3}?

5. What is the **mass** (in tonnes) of a rocket taking off from the Earth's surface if a thrust of 3·2 x 10^5 N from the engines produces an upward acceleration of 0·67 ms^{-2}? ('g' = 10 Nkg^{-1}).

6. What are the (a) **mass** and (b) **weight** of a man on the surface of the Earth, where 'g' is 9·8 Nkg^{-1}, if his weight on Mars is 288 N?

7. Calculate the **celsius** temperature of a fixed mass of gas in a rigid container if its **pressure** has increased from 1·2 x 10^5 Pa at 12^{o}C to 2·8 x 10^5 Pa.

8. On Mars, where the gravitational field strength is 3·7 Nkg^{-1}, a stone is projected horizontally at 24 ms^{-1} from the edge of a cliff which is 200 m high. After what **time** would the stone be falling at an angle of 45^o to the vertical?

9. What **minimum** power output would a crane's electric motor generate to lift a crate at a **steady** vertical speed of 0·12 ms^{-1} if the crate measures 2 m x 2·5 m x 1·5 m and has an average density of 3·5 x 10^3 kgm^{-3}?

10. When travelling at 30 ms^{-1}, a car's engine cuts out and it starts to decelerate because of frictional forces. If the frictional forces total 1 kN and remain constant and the car's mass is 1600 kg, how **fast** is it moving after 4 seconds?

11. For an object accelerating from **rest**, which quantity is calculated by taking the **square root** of double the **product** of acceleration and displacement?

12. A sailor runs across a ship, at 90^o to the ship's direction of motion, covering 20 metres in 4 seconds. If the ship is moving through the water at 7 ms^{-1}, what is the speed of the sailor relative to the **water**?

Exercise 11

1. What is the more usual **name** for the '**joule per coulomb**'?

2. What is the **potential difference** across a 10 Ω resistor when a current of 2·5 A flows through it?

3. How much **charge** flows through a lamp in 2 minutes if it carries a **steady** current of 0·3 amperes?

4. What is the **total** resistance of two 10 Ω resistors connected to each other (a) in series and (b) in parallel?

5. What **current** is carried in the element of a 2·4 kW kettle connected to the 230 V mains?

6. What **power** is dissipated in a 48 Ω resistor when 2 amps flows through it?

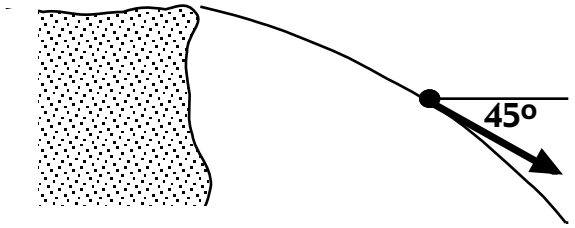
7. How much **energy** is converted into heat when 2 coulombs of charge moves through a resistor across which there is a **p.d.** of 12 volts?

8. A parachutist of mass 80 kg is falling down to the ground at a steady vertical velocity of 10 ms^{-1}. What is the value of the total **drag** force acting on him? (Take g = 10 Nkg^{-1}).

9. Express 'normal room temperature' of 20ºC in **kelvin**.

10. When a certain liquid is boiled to form a gas, the **average** spacing of its particles increases by a factor of 9.3. To the nearest **ten**, by what factor does the **volume** of the substance increase?

11. A stone is thrown **horizontally** from the edge of a cliff at 24·5 ms^{-1}. Ignoring the effect of air resistance and taking 'g' as 9·8 ms^{-2} , calculate how **long** after being thrown the stone's motion makes an angle of 45º to the horizontal.



12. An object, travelling at 10 ms^{-1} in a straight line, starts to accelerate and, after 2 seconds, has travelled 24 metres. How much ***further*** would it have travelled in the same time with **double** the acceleration?

Exercise 12

1. When supplying a certain current to an external load, the p.d. across a battery of e.m.f. 12 volts is measured as 9·5 volts.
   What is the value of the '**lost volts**'?

2. What **current** is flowing through a 1.5 kΩ resistor when the p.d. across it is 1·5 V?

3. What is the **p.d.** across a lamp if 24 joules of electric energy are transferred to other forms when 8 coulombs of charge has passed through it?

4. Two resistors in **parallel** have an effective resistance of 20 Ω. One of the resistors is 30 Ω. Calculate the value of the other.

5. How does the **total** resistance of **any two** resistances **connected in parallel** compare to the value of **either** of the individual resistances?

6. Calculate the **power dissipated** in a 60 Ω resistance wire carrying a current of 4 amps.

7. By what **name** is the 'volt per amp' better known?

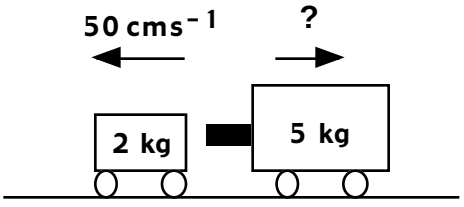
8. Find the **kinetic energy** gained by an object carrying a charge of 2 nanocoulombs accelerated across a gap by potential difference of 120 kilovolts. (1 nanocoulomb = 10^{-9} coulomb)

9. What is the **turns ratio** in an **ideal** transformer (100% efficient) which steps down mains voltage of 230 V a.c. to 6 V a.c.?

10. What are the magnitudes of the **maximum** and **minimum** resultant forces which can be made with two forces, magnitudes 20 N and 25 N respectively?

11. A brick, lowered into a bucket of water, displaces 1 kg of water and '***weighs***' 50 newtons when in the water. What is the weight of the brick in the air if the water produces an upthrust of 10 N?

12. Two trolleys are at **rest** and in contact on a smooth, level surface. A coiled spring in one trolley is released so that they 'explode' apart. The lighter trolley moves off at 50 cms^{-1}.
    Find the **speed** of the other trolley and the **minimum energy** which was stored in the coiled spring before release.



Exercise 13

1. The '**lost volts**' in a battery measure 3 volts when it is delivering a current of 2 amps to an external load. Calculate the size of the **internal resistance** of the battery.

2. A lamp operating at its normal rating of 2·5 V 0·3 A is switched on for 5 minutes. How much **energy** is used by the lamp during this time?

3. An old moving coil voltmeter has a resistance of 10 kΩ. How much **current** is passing through it when it reads 5 volts?

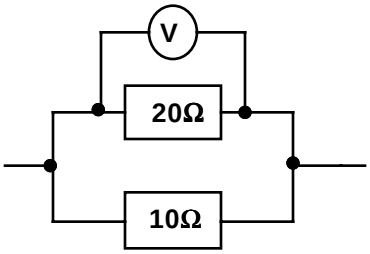
4. Two resistors connected in **parallel**, one of which is 10 Ω, have a **total** resistance of 5 Ω. Calculate their **total** resistance when connected in **series**.

5. A typical lightning strike delivers a charge of 20 coulombs in 1 millisecond. Calculate the average **current** during the strike.

6. If the average p.d. between the cloud and the ground during the above lightning strike is 50 million volts, calculate the **energy** transferred by the strike.

7. A hair drier has a heating element and a fan motor. Should they be wired in **series** or **parallel**? How should the **switches** be wired?

8. Two resistors, 10 Ω and 20 Ω, are connected in **parallel** in a circuit. A voltmeter connected across the 20 Ω resistor reads 10 volts. What would it read if connected across the **other** resistor?



9. What is the **reaction** to the force of a footballer's foot on the ball?

10. Describe the **shape** of graph which would be obtained if, for a moving object of a certain mass, its kinetic energy at different velocities was plotted against the **square** of its velocity.

11. A pupil expressed the result of an experiment as 240 N $^{+}$/- 16 %. Express the result with the error in **absolute** form, to the nearest 10 N.

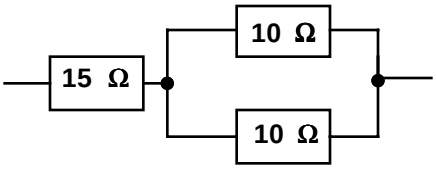
12. A piece of wood with a mass of 30 grams has a volume of 25 cm^3. Calculate its **density** in **kgm^{-3}**.

Exercise 14

1. A circuit has to be protected by a 10 A fuse but there are only two **5 A** fuses available. How could they be connected to protect the circuit?

2. What is the **resistance** of the filament of a 230 V 60 W lamp when operating at its proper rating?

3. Calculate the **total** resistance of a 15 Ω resistor in **series** with two **parallel** 10 Ω resistors.



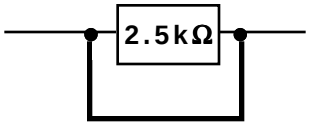
4. What is the **p.d.** across the terminals of a battery of e.m.f. 12 V and internal resistance 1 Ω when supplying current to an external load of 23 Ω?

5. Calculate the **current** in a set of twenty 12 V 1·2 W Xmas tree lights wired to the 230 V mains.

6. What is the **power** rating of a 529 Ω light bulb which operates from the 230 V a.c. mains?

7. When 3 coulombs of charge flows through a cell, 3.6 joules of chemical energy is converted to electrical energy. What is the **e.m.f.** of the cell?

8. What is the **effective** resistance of a 2.5 kΩ resistance **short-circuited** by a length of thick conducting wire?



9. What is the **effective** resistance across

   (a) an **open** switch, (b) a **closed** switch?

10. The pressure at a depth of 0·5 metres in a certain liquid is 4500 Pa above atmospheric pressure. At what **depth** would the pressure rise to 13·5 kPa?

11. The pressure at a certain depth of fresh water is 20 kPa above atmospheric pressure. What would the **pressure** be at the **same** depth in another liquid with a density **1·3 times** that of water?

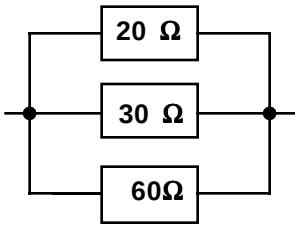
12. A boy jumps from the top of a 4 metre diving board. Calculate his **speed** just before hitting the water, ignoring the effect of air resistance and taking 'g' as 9·8 Nkg^{-1}. (Assume he falls vertically).

Exercise 15

1. By what **name** is the unit 'volt-ampere' better known?

2. The p.d. across a 12 Ω resistor in a circuit is 1·7 volts. What would be the **p.d.** across a 24 Ω resistor in the **same** circuit and in **series** with the first resistor?

3. Calculate the **total** resistance of three resistors connected in **parallel** of resistances 20 Ω, 30 Ω and 60 Ω respectively.



4. Which **quantity** is calculated by the **square** of the p.d. across a resistor **divided** by the value of its resistance?

5. How much **energy** is transferred from chemical to electrical when 10 coulombs of charge pass through a cell of **e.m.f.** 1·5 volts?

6. A battery of e.m.f. 4·5 V and internal resistance 1·0 Ω is in series with a switch and a lamp of resistance 8·0 Ω. What would a voltmeter connected across the battery **read** with (a) the switch **open** and (b) the switch **closed**?

7. A car battery is rated as 40 Ah (amp-hours).
Which **quantity** is measured by this unit?

8. What can always be stated about the **current** at all points in a **series** circuit?

9. The gravitational acceleration near the surface of Mars is 3·7 ms^{-2}. A rock **free falls** from the top of a 200 metre high cliff.
How **long** would it take to reach the foot of the cliff and what would its **maximum speed** be?

10. How much **work** would be done in slowly lifting a 50 kg box from the floor to a table which is 80 cm high?

11. The air inside a bicycle pump is at atmospheric pressure ($1·01 \times 10^5$ Pa). The hole is blocked and the piston slowly pushed in till the air inside is reduced to **one quarter** of its original volume.
What is the **air pressure** inside the pump now?

12. A digital voltmeter gives the reading 2·34 V. Write this value with the implied **reading error** stated.

Exercise 16

1. What is the total **e.m.f.** and **internal resistance** of two cells, each of e.m.f. 1·5 volts and internal resistance 1·2 Ω, connected (a) in **series** and (b) in **parallel**?

2. The p.d. across a source supplying current to an external load of three resistors measures 12 volts. The p.d. across each resistor measures 6 volts. Is this **possible**?

3. Which **unit** is otherwise known as the '**coulomb per second**'?

4. Calculate the 'on' **resistance** of a mains 60 watt lamp, taking the voltage as 230 V r.m.s.

5. Two 1 kW electric fire elements are normally wired in parallel to give a power output of 2 kW when connected to 230 V. If they were connected in **series** to 230 V, what would their power output be? (Assume their resistance is **constant** at all temperatures).

6. Three resistors connected in parallel have an effective resistance of 10 Ω. **Two** of them are **each** 40 Ω. What would be the total resistance of the three resistors if connected in **series**?

7. A rechargeable cell is designed to be charged at 120 mA for 16 hours. Calculate the total **charge** delivered to the cell in that time.

8. A battery of e.m.f. 12·0 V has lost volts of 2·0 V when delivering a current of 1·0 amp to an external load. Calculate the **internal resistance** of the battery and the **potential difference** across its terminals.

9. A fireworks rocket 'burns out' at a height of 150 m and a speed of 40 ms^{-1}. What is its **acceleration** 1 second later, neglecting air resistance?

10. A shell is fired from a cannon with a muzzle velocity of 200 ms^{-1} at an angle 30^{o} to the horizontal. How **long** does it take to reach its maximum height and how **far** does it travel before hitting the ground? (Take 'g' = 10 ms^{-2}).

11. What **impulse** causes a 160 g ball moving at 10 ms^{-1} in one direction to change to a speed of 20 ms^{-1} in exactly the opposite direction?

12. What temperature ***rise*** would cause a fixed volume of gas with a pressure of $1{\cdot}2 \times 10^{5}$ Pa at 10^{o}C to increase in pressure to $1{\cdot}4 \times 10^{5}$ Pa?

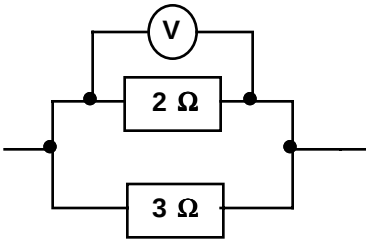
Exercise 17

1. The terminal potential difference of a battery of e.m.f. 12 volts falls to 11 volts when delivering a current of 0·5 amps to an external load. What is the **internal resistance** of the battery?

2. The t.p.d. of a battery of e.m.f. 12 V and internal resistance 1 Ω falls to 11 V when delivering current to an external load resistor. A second, identical resistor is connected in parallel to the first. Calculate the new **t.p.d**.

3. What is the more common **name** for the unit '**amp-second**'?

4. A voltmeter reads 1·8 V when connected across a 2 Ω resistor which is connected in **parallel** to a 3 Ω resistor. What would the voltmeter read if connected across the 3 Ω resistor?



5. What is the **peak voltage** of the 230 volt r.m.s. mains?

6. What is the **capacitance** of a capacitor which holds 19·8 mC of charge when there is a voltage of 9 volts across its plates? (Answer in **microfarads**).

7. Calculate the **energy stored** by a 1000 μF capacitor charged fully from a 12 V battery.

8. Sketch the **shape** of a graph of '**current against time**' for a charging capacitor from uncharged to fully charged.

9. A 5000 μF capacitor is in series with a 9 V battery and a 1000 Ω resistor. What is the **maximum** charging current?

10. Does a capacitor **block** d.c. or a.c.?

11. A car tyre's pressure is checked at 30 units when the air temperature inside it is -2°C. After a journey, the pressure is checked again and found to have risen to 32 units. Assuming no change in volume, what is the new **temperature** of the air inside the tyre?

12. **Which** of these quantities in an experiment to measure the unbalanced force on a trolley will have the **bigger** effect on the error in the calculated force:

    $a = 2{\cdot}0 \pm 0{\cdot}4\ ms^{-2}$; $m = 2200 \pm 200\ kg$?

    Explain. Calculate the size of the **force** and its **absolute** error.

Exercise 18

1. Which **quantity** is found by calculating the **area** under the line on a graph of charge against potential difference for a capacitor?

2. How much **energy** is converted to heat when 2 millicoulombs of charge pass through a resistor across which there is a voltage of 9 volts?

3. How much **energy** is stored in a capacitor charged to 9 volts with a charge of 2 millicoulombs on its plates?

4. Sketch the **shape** of graph which would be obtained of voltage against time for a **charging** capacitor from uncharged to fully charged.

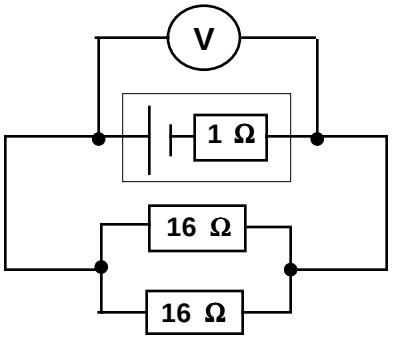
5. How much **energy** is stored in charging a 5000 μF capacitor to 12 V?

6. The **peak** voltage of an a.c. supply is measured on the screen of a CRO, with the Y-gain set at 5 V/cm, as '3.4 cm'. Calculate the **r.m.s. voltage** of the supply.

7. A tungsten filament lamp is in series with an a.c. ammeter and a **constant voltage**, variable frequency supply. The current is measured as 300 mA at a frequency of **50** Hz.
   What would it be at (a) **100** Hz and (b) **200** Hz?

8. A 2000 μF capacitor, in series with a resistor, is charged from a 12 V battery. The initial charging current in measured as 36·4 mA. Calculate the **resistance** of the resistor.

9. Two resistors of value 16 Ω are connected in **parallel** and serve as a load to a battery of e.m.f. of 9 V and internal resistance 1 Ω. What would a voltmeter connected across the battery **read**?



10. What is the **difference** between 20ºC and 20Cº?

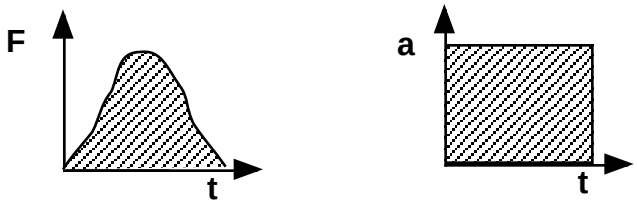
11. A train, travelling at 60 ms^{-1}, decelerates uniformly to rest at 2 ms^{-2}. How **far** does it travel during the braking?

12. For the following measurements made of a trolley's mass, in kilograms, calculate the **best estimate** of the true value of the mass and its **random error**:

2·61 2·54 2·56 2·49 2·50 2·53

Exercise 19

1. Calculate the **charge** on the plates of a 5000 μF capacitor **fully** charged by a 12 volt battery.
2. Calculate the **energy** stored by the capacitor in question 1.
3. A capacitor, charged to 12 volts, stores 0·72 joules of energy. What is the value of its **capacitance**, in microfarads?
4. A capacitor is in a circuit driven by a variable frequency a.c. supply. The p.d. across the capacitor is kept **constant** and the frequency of the current altered. At **50** Hz, the current through the capacitor is found to be 300 mA. What would the current be at (a) 100 Hz and (b) 200 Hz?
5. An alternating current with a **peak** value of 7·1 amps flows through a 60 Ω resistance. Calculate the **average power** dissipated by the resistance.
6. What are the **output voltages** for an op-amp in the inverting mode, powered by a 15-0-15 volt supply, where R_1 = 1k, R_f = 10k for these input voltages:
   (a) 0·5 V, (b) -0·2 V, (c) 0 V, (d) -1·2 V, (e) 5 V ?
7. Write down the **formula** for the output voltage for a **differential** amplifier and say why it is called 'differential'.
8. Draw **possible** circuit diagrams for (a) an inverting amplifier of **10x** gain and (b) a differential amplifier which multiplies the voltage difference by **50**.
9. Draw a **possible** circuit diagram for an inverting amplifier which will **add** one input voltage, V_1, to **double** a second input voltage , V_2.
   Write down a formula for $\mathbf{V_o}$ in terms of the two input voltages.
10. Sketch the **shape** of graph for **pressure** against **absolute temperature** for a fixed mass of gas at constant volume.
11. Which **quantities** are found from the areas under the lines of (a) a force-time graph and (b) an acceleration-time graph?



12. The error in a pressure gauge is stated by the manufacturer to be 10%.
    For a reading of 2·1 x 10^5 Pa, write down the **range** within which the **true** value of the pressure is **likely** to fall.

Exercise 20

1. With $R_1 = R_2 = 1k$ and $R_3 = R_f = 100k$, a differential amplifier is used to amplify the p.d. from an out-of-balance Wheatstone bridge. If the **input** voltage from the bridge is 120 mV, what is the size of the output **voltage** from the amplifier?

2. What determines the **maximum** output voltage of an op-amp?

3. Write down the formula for the output voltage of an **inverting** amplifier and explain the significance of the '**-ve**' sign.

4. A pupil wants to use a 5 volt filament lamp as an indicator for a temperature sensor which contains a differential amplifier. The lamp is connected across the output of the amp which a voltmeter shows to have a voltage of 5 volts. However, the lamp fails to light up.
   Explain why; (It is **not** broken). Suggest what could be added to the circuit to enable the lamp to light.

5. In a **balanced** Wheatstone bridge circuit, the galvanometer reads zero. The driver cell's voltage suddenly drops by 25 %.
   What, if anything, happens to the galvanometer reading?

6. What internal **resistances** should (a) an **ideal** ammeters and
   (b) an **ideal** voltmeters have?

7. Calculate the **charge** on the plates of a 2200 μF capacitor which stores 0·09 joules of energy.

8. The primary winding of an **ideal** transformer has 6000 turns. It steps down 230 V a.c. to 8 V a.c. Calculate the number of turns on the secondary winding.

9. A water pump, rated at 12 V; 5 A raises 30 kg of water through a height of 2 m in a time of 15 seconds. Calculate the pump's **efficiency**. (Assume the water has no kinetic energy on reaching the top and take 'g' = 10 Nkg^{-1}).

10. In an experiment to measure the specific latent heat of fusion of ice, it is found that a 45 watt heater melts 300 grams of ice at 0ºC into water at 0ºC in 40 minutes. What **value** would these results give for the quantity being measured?

11. 72000 J of heat are needed to raise the temperature of a 2 kg block of ice removed from a freezer at -18ºC to its melting point. Calculate the **specific heat capacity** of ice suggested by these figures.

12. In experiments involving heat, what is usually the **largest** source of error?

Exercise 21

1. Calculate the **frequency** of a water wave which has a wavelength of 1·5 m and travels a distance of 10 metres in 5·0 seconds.

2. What is the **period** of a wave whose frequency is 4 Hz?

3. A ray of light makes an angle of incidence of 40º with the **normal** between air and a liquid. The angle of refraction in the liquid is 28º. Calculate the value of the absolute refractive index of the liquid.

4. Which of the following **properties** of a wave will certainly **not** change when the wave moves from one medium to another: velocity, wavelength, frequency, shape?

5. The critical angle for a particular kind of glass is 47º. Describe what would happen to a ray of light travelling through the glass and incident on its boundary with the air at (a) **49º** and (b) **41º** to the normal.

6. The index of refraction of a kind of glass for a certain wavelength of red light is 1·51. It is 1·55 for violet. A ray of white light is incident on a prism made of the glass at 30º to the normal. Calculate the angle **between** the red and violet rays in the **glass**.

7. The intensity of radiation from a point source of light is found to be 100 units at a distance of 2 metres from the source. What would the intensity be at (a) **1 metre**, (b) **4 metres** and (c) **10 metres** from the source?

8. Calculate the **speed** of light through glass with a refractive index of 1.5. (Speed of light in a air = 3×10^8 ms^{-1}).

9. Sketch one **possible** arrangement of the following components which would give a **balanced** Wheatstone bridge: centre-zero galvanometer, 1·5 V cell, 10 k, 1 k, 330 Ω and 3·3 k resistors and connecting wires.

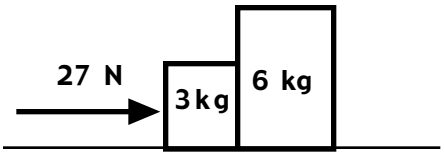
10. A metre bridge, with a standard resistor of 1000 Ω and an unknown resistor **X**, is found to balance at ℓ = 40 cm. With no further information given, calculate ***two*** possible values for resistor **X** .

11. By what **name** is the unit '**coulomb per volt**' better known?

12. A boy reads a thermometer one degree **too low** consistently, because he fails to hold it at eye level. Of what **type** of error is this an example?

Exercise 22

1. Calculate the **critical angle** for water which has a refractive index of 1·33.
2. What is the **frequency** of a wave of red light in the air where its wavelength is $6{\cdot}8 \times 10^{-7}$ m?
3. For the wave of red light in Q2, what would be (a) its **wavelength** and (b) its **frequency** if it passed from air into glass with a refractive index of 1·5?
4. Two masses are pushed along a smooth, horizontal surface by a force of 27 N. There is **no** friction.
   Calculate the **acceleration** of the masses and the **force** pushing the **6 kg** mass.



5. A plane water wave of wavelength 4 cm passes through two equal gaps in a barrier, creating an interference pattern on the other side. At a certain point, an area of undisturbed water is observed. Give **three** possible values for the **path difference** between the point and the centre of each of the gaps.
6. What would be the observed effect on the **sound** if two hi-fi loudspeakers were wired incorrectly so that one speaker was **out of phase** with the other?
7. The intensity of light at a distance of 1·5 metres from a point source is measured to be 2·4 Wm^{-2}. At what **distance** from the source would it fall to 1·2 Wm^{-2}?
8. Given a set of results for the measured intensity of light (**I**) from a point source at a number of distances (**d**) from the source, what **graph** should be plotted to yield a **straight line through the origin**?
9. The average intensity of the sun's radiation at the surface of the Earth is 1500 Wm^{-2}. What **power** would be incident on a square of side 50 cm?
10. Assuming no heat loss to surroundings, how **long** should a 40 W heater take to raise the temperature of 150 g of water by 25 C^{o}?
11. After a long journey, a car tyre's pressure is 30·5 units at a temperature of 25ºC. During the night, its pressure falls to 26·9 units. What was the **temperature** of the air in the tyre during the night? (Assume no change occurs in the tyre's volume).
12. What happens to the **speed** of the particles in a gas as its temperature increases?

Exercise 23

1. Calculate the **wavelength** of light in water of absolute refractive index 1·33 which has a wavelength of 347 nm in **glass**. (n = 1·50).

2. A ray of monochromatic light, travelling through glass, is incident on the glass/air boundary at an angle of 60^o to the **surface** of the glass. Calculate the angle it makes with the **normal** in the air, if the absolute refractive index of the glass is 1·52.

3. A plane water wave is incident on a gap in a barrier. The width of the gap is approximately the same as the wavelength of the water wave. Describe the wave as it **emerges** from the gap.

4. A water wave, travelling at 2·5 ms^{-1}, has a wavelength of 50 cm. What is the **period** of the wave?

5. Above what angle to the normal will light be **totally internally reflected** striking the surface of glass of absolute refractive index 1·49? (Assume that the glass is surrounded by air).

6. A ray of monochromatic light, travelling through air, makes an angle of 30^o with the **surface** of a rectangular block of a certain type of transparent plastic. It makes an angle of 53^o with the **surface** inside the plastic. What is the value of the plastic's absolute **refractive index**?

7. Certain X-rays have a frequency of 1·0 x 10^{19} Hz. Calculate their **wavelength** in the air.

8. Radio 4 is broadcast on 1500 m on the Long Wave. Calculate the **frequency** of the carrier wave in **kilohertz**.

9. Which **unit** could be otherwise described as a '**square volt per ohm**'?

10. A 10000 µF capacitor is fully charged by a 9 volt battery. Calculate

    (a) the **work done** by the battery and (b) the **energy stored** in the charged capacitor. Account for the difference between (a) and (b).

11. What are the size and direction of the **unbalanced force** acting on a 2·6 kg stone travelling through the air at 30 ms^{-1} at an angle of 30^o above the horizontal? (Ignore the effects of air resistance).

12. What is the approximate **change** in (a) **volume** and (b) **average particle spacing** when a liquid is totally changed into a gas?

Exercise 24

1. A car, travelling at a speed of 30 ms^{-1} in a straight line, brakes and decelerates at a uniform rate of 2 ms^{-2}. How much **further** does it travel before coming to rest?

2. A 73 kg man, at home in a Moon base (where the gravitational field strength is 1·7 Nkg^{-1}), is afloat in his bath. Calculate the **upthrust** exerted on his body by the water in the bath.

3. The air in a bicycle pump, with the plunger pulled out, has a volume of 100 cm^3. The pump is open to the air, where the pressure is 1·01 x 10^5 Pa. The outlet hole is now blocked and the plunger pushed slowly in until the volume is just 20 cm^3. Calculate the new **air pressure** inside the pump.

4. The air in a sealed flask exerts a pressure of 1·50 x 10^5 Pa on the walls of the flask when its temperature is 26ºC. What would the **pressure** become if the flask was immersed in a large container of ice and water?

5. A group of students measured the mass of a bar of soap and obtained these measurements:
   18·1 g, 18·2 g, 18·0 g, 18·6 g, 18·0 g, 17·8 g, 18·5 g, 18·1 g 17·9 g, 18·2 g, 18·3 g, 17·8 g.
   Calculate the **best estimate** of the true value of the soap mass and its approximate **random error**.

6. Calculate the **peak** value of an alternating voltage of **160** V r.m.s.

7. What value of resistor, connected in **series** to a 20 Ω resistor, would create a total resistance of **four times** that produced if it was connected in **parallel** to the 20 Ω resistor?

8. The mains electricity in some countries has a frequency of 60 Hz. Calculate the **period** of one cycle of the supply.

9. Light has a wavelength of 348 nm in a block of glass of refractive index 1·5.
   What is its wavelength when it emerges into the **air**?

10. Light, travelling from water (n = 1·33) into glass (n = 1·51), enters the glass at an angle of 45º to the normal. Calculate the **angle** it makes with the normal in the **glass**.

11. Calculate the **critical angle** for diamond (n = 2·4).

12. Which of these '**properties**' of a wave **always** change when the wave is **refracted**: speed, frequency, wavelength, direction?

Exercise 25

1. Light, moving through water (n = 1·33) strikes a block of glass (n = 1·51) at an angle of 40^o to the normal. What **angle** does the light make to the normal inside the **glass**?

2. Calculate the **energy** carried by a photon of light of wavelength 540 nm in the air.

3. A 2000 μF capacitor in series with a 2200 Ω resistor is to be charged from a 9 volt battery. What is the **maximum** charging current, in milliamps?

4. A bell transformer, operating from 230 V a.c., has an output of 8 V a.c. Calculate the **turns ratio** of the transformer.

5. A **digital** voltmeter reads 2·4 volts. State the implied **reading error** both as an absolute value and as a percentage.

6. A brick of mass 4 kg is supported underwater by a newton balance which reads 24 newtons. What is the **upthrust** on the brick? (Take g = 10 Nkg^{-1}).

7. The leg of a tripod stand exerts a force of 30 N at an angle of 20^o to the vertical. If the tripod leg has a flat 'foot' which makes contact with the bench of area 2 cm^2, calculate the **pressure** exerted by the leg on the bench.

8. A car, in overtaking another vehicle, accelerates uniformly in a straight line from 20 ms^{-1} to 30 ms^{-1} in 5 s. Calculate the car's **average speed**, its **acceleration** and the **distance moved** during the acceleration.

9. How much **work** is done against **friction** in dragging a 4 kg box at a **steady** velocity with a force of 45 newtons up a uniform slope of 30^o up to the point where the **height** of the box has increased by 10 metres?

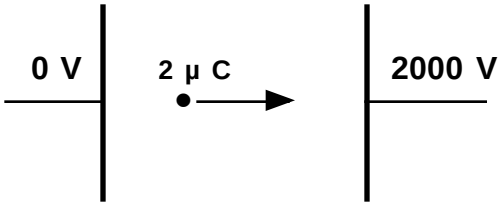
10. In slowing down by use of the brakes, a car's speed is reduced from 50 ms^{-1} to 30 ms^{-1}. If the brakes and other frictional forces acting on the car generate 1·04 MJ of heat due to the reduction in speed, find the value of the car's **mass**.

11. Calculate the **specific heat capacity** of a 3 kg piece of metal which experiences a temperature rise of 25 C^o when heat is supplied to it at a rate of 60 watts for 10 minutes, if a total of 3000 joules **escapes** to the surroundings.

12. The density of mercury is 13600 kgm^{-3}. What **weight** of mercury would fill a 250 cm^3 container? (Take g = 10 Nkg^{-1}; 1 m^3 = 1 000 000 cm^3).

Exercise 26

1. Calculate the **kinetic energy** gained by an object carrying a charge of 2 µC accelerated from **rest** across a potential difference of 2 kV.



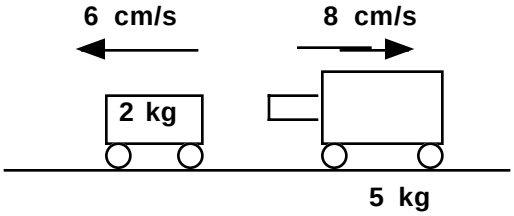
2. In entering a transparent material from the air, the wavelength of a laser's light decreases from 600 nm to 451 nm. Calculate the **refractive index** of the material.

3. The critical angle of a particular type of glass is 38.4º.
What is its **refractive index**?

4. With the **time base** of a CRO set at 0.5 ms/cm, three cycles of an alternating voltage, displayed on the screen, occupy 6.0 cm, horizontally.
Calculate the **frequency** of the supply voltage.

5. If the intensity of a **point** light source measures 100 units at a distance of 2 metres from the source, at what **distance** would the intensity be 50 units?

6. Two trolleys have just '**exploded**' apart on a smooth, horizontal surface, as shown. What was their **combined velocity** just **before** the event?



7. How much **energy** is stored by charging a 2200 µF capacitor to 9 volts?

8. Calculate the **power dissipated** by an 80 Ω resistor connected to a 240 V supply.

9. A badly made thermometer consistently reads two degrees **too high**.
What name is given to this type of **error**?

10. Assuming no heat is lost to the air or other surroundings, what **temperature** would 490 g of water reach, starting at 15ºC, if a 60 watt heater delivered heat to it for 20 minutes?

11. How much **heat** is required to melt 40 grams of ice (at its melting point)?

12. A hydroelectric power station generates 44 MW of electric power from an input of 70 MW of water power. Calculate the **efficiency** of the power station.

Exercise 27

1. A red laser beam with a power of 1 mW is incident on a screen.
   If the wavelength of the light is 6.3×10^{-7} m, calculate the **number** of photons reaching the screen in one second.

2. At what **speed** would light travel in glass of refractive index 1.54?

3. A gas bubble of volume 3 cm^3 forms at the bottom of a loch where the pressure is 3 atmospheres and the temperature 4ºC. What is its **volume** on reaching the **surface** where the water temperature is 13ºC?

4. Two men are pushing a broken down car, mass 1800 kg, along a horizontal road with a combined horizontal force of 1000 N. At one instant, the car accelerates at 0.25 ms^{-2}. What is the value of the **frictional force** acting on the car at this **instant**?

5. A 200 g ball rolling along a level surface at 80 cms^{-1} bounces off a wall and returns along the **same** path at 70 cms^{-1}. Calculate the **size** and **direction** of the change in the ball's momentum.

6. What is the **reaction** force to the gravitational force exerted by the Earth on the Moon?

7. How **long** would a stone, thrown horizontally from the top of a 122.5 m high cliff, take to reach the sea below? Would the horizontal speed matter?

8. A loaded shopping trolley, of mass 83 kg, has a sticky wheel. This causes the frictional resistance to be 100 N at low speeds. Calculate, to the nearest whole degree, the **angle** of slope down which the trolley would run at a **steady speed**.

9. A 6 volt lamp is operated at its rated value. How many **joules** of heat and light energy are produced when 3 coulombs of charge pass through the lamp?

10. Three resistors, **10 Ω**, **10 Ω** and **20 Ω**, are connected in parallel to each other. A high resistance voltmeter connected across the **20 Ω** resistor reads 3 V. What would the **reading** be across **each** of the other resistors?

11. A 10000 µF capacitor, in series with a 2200 Ω resistor, is being charged from a 9 V battery. At one instant, the potential difference across the capacitor is 3.7 volts. At this instant, what is the **p.d.** across the resistor, the **current** in the circuit and the **charge** on the capacitor plates?

12. The galvanometer in a **balanced** Wheatstone bridge reads zero. The resistance of **one** of the resistors gradually increases in size. Sketch a graph to show how the **current** would vary with the **change** of resistance. (Assume the change of resistance is less than 10% of the starting value).

Exercise 28

1. A certain radio station broadcasts on a frequency of 101.7 MHz. Calculate the **wavelength** of the radio wave.

2. A ray of light enters an oblong glass block at an angle of 40º to the **surface** of the glass. The refracted ray makes an angle of 61º to the **surface** of the glass.

   What is the **absolute refractive index** of the glass?

3. What are the **optical powers** of lenses with a focal lengths of (a) 7.1 cm, (b) 5 cm (c) - 10 cm ?

4. What is the '**wavelength**' of a photon in air which carries energy of 6.61×10^{-19} J and in what **part** of the electromagnetic spectrum would it be found?

5. A photon of U.V. with a wavelength of 325 nm hits the surface of a metal and ejects a photoelectron. If the **threshold** frequency for the metal is 4.84×10^{14} Hz, calculate the maximum **kinetic energy** of the electron.

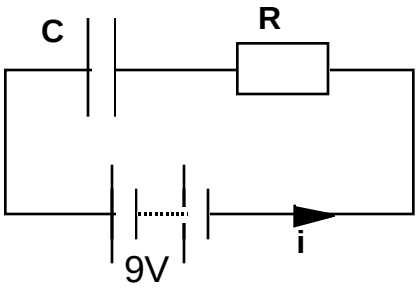
6. Sketch the arrangement of four resistors, values **1 Ω**, **1 Ω**, **3 Ω** and **6 Ω** which would give a **total** effective resistance of **1 Ω**.

7. Calculate the value of the '**lost volts**' when a cell of e.m.f. 9.0 volts and internal resistance 2.0 Ω delivers current to an external load of 16 Ω. What would be the **potential difference** across the cell's **terminals?**

8. A 2000 µF capacitor is charged with 18 mC on its plates. Calculate the **energy stored** and the **potential difference** across its plates.

9. A torch bulb is rated 2.5V0.3A. Calculate the **resistance** of its filament and its **power** consumption during normal operation.

10. A 5000 µF capacitor is in **series** with a 2500 Ω resistor and is being charged from a 9 volt battery. Calculate the charging **current** at the instant when the voltages across the resistor and capacitor are **equal** and the **charge** on the capacitor's plates.



11. Which **unit** could be expressed otherwise as the '**square coulomb per farad**'?

12. At the surface of the Moon, the gravitational field strength is approximately $1.7\ \text{Nkg}^{-1}$. How **long** would a **1 kg** rock take to fall to the bottom of a 3050 metre high crater, projected horizontally from the edge?

    How long would a **2 kg** rock take to fall?

Exercise 29

1. A shell is fired from a field gun with a muzzle velocity of 600 ms^{-1} at an elevation of 40º to the horizontal. Ignoring the effects of air resistance, calculate its **horizontal range** and the **greatest height** reached.

2. What is the Earth's **gravitational field strength** at the distance of a **geostationary** orbit if a 4500 kg satellite is attracted to the Earth by a force of 1035 newtons?

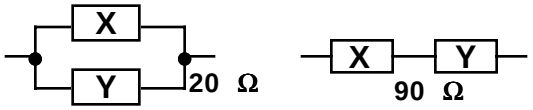
3. A 60 kg boy, standing on a set of scales in an upward moving lift, appears to weigh 690 N. What is the **actual** weight of the boy and what is the **motion** of the lift?

4. An oblong, waterproof object measures 2 cm x 8 cm x 18 cm. It weighs 3.5 N. When lowered into water, show whether the object will **float** or **sink**.

5. The specific latent heat of vaporisation of ethanol is 850 kJ kg^{-1}. How many **grams** of ethanol would **evaporate** if 4500 joules of heat was delivered to a container of ethanol at its boiling point of 79ºC?

6. Experiment shows that, of 600 joules of electricity delivered to a filament lamp, 440 joules turns into heat energy. Calculate the **efficiency** of the lamp at converting electric energy to **light** energy.

7. What **values** have two resistors **X** and **Y**, which, when connected in **series**, make a total resistance of **90 Ω** and, when in **parallel**, make a total resistance of **20 Ω**?



8. Which **graph's area** can be calculated to give the **impulse** of the force acting on an object? Which **other** quantity is calculated by this area?

9. Convert 300 cm^3 into **cubic metres** and 300 cm^2 into **square metres**.

10. Using a **calculator**, calculate the values of (a) $\mathbf{10^5 \div 2.5}$ (b) $\mathbf{4.2 \times 10^3 \div 10^6}$, (c) $\mathbf{(10^{-2})^3}$ and (d) $\mathbf{10^{-2} \times 10^{-3}}$

11. A girl carries a box of mass 4 kg along a level floor for a total distance of 5 metres at a constant **height**. How much **work** does the girl do against the force of gravity? **Explain**.

12. Two rays of light, travelling through glass (n = 1.51) which is under water (n = 1.33), strike the surface at angles to the normal of 59º and 63º respectively.
Determine what **happens** to **each** ray and what angle **each** makes to the normal.

Exercise 30

1. A CRO has the time base set at 10 mscm^{-1}. How many **centimetres** would **one** cycle of a 25 Hz signal occupy on the screen, horizontally?

2. A hockey ball is lifted at an angle of 60^{o} to the horizontal. If it leaves the stick 80 cm above the pitch at 20 ms^{-1}, find its **greatest height** above the pitch and how **long** it takes to reach its highest point. (Ignore air resistance).

3. What **impulse** is imparted to a 50 g tennis ball if, travelling at 40 ms^{-1}, it is struck by a racquet and returned in the opposite direction at 50 ms^{-1}?

4. Calculate the **work done** by an unbalanced force in accelerating a car of mass 2 tonnes from rest at 1.5 ms^{-2} in a straight line for 10 seconds.

5. In part of an electric circuit, two resistors, values **3 Ω** and **6 Ω** are connected in **parallel**. If the current flowing through the **3 Ω** resistor is **4 A**, what **current** flows through the other and what is the **voltage** across each?

6. Calculate the value of the **output voltage** from a differential amplifier where: V_1 = 3.2 volts, V_2 = 3.0 volts, $R_f = R_3$ =100 kΩ, $R_1 = R_2$ =2 kΩ. (The power supply for the amplifier is 15-0-15 volts).

7. A capacitor stores 0.36 joules of energy when fully charged from a battery of e.m.f. 12 volts. What is the value of the **capacitance**?

8. A fireworks rocket with a mass of 40 g is set off. Immediately on lift off, its acceleration is measured at 25 ms^{-2}. Calculate the **thrust** developed by the rocket at lift off. (Assume the effect of air resistance is negligible).

9. Calculate the **resultant force** (magnitude and direction) of two forces, **6 N** and **9 N** which have an angle of **35^{o}** between them.

10. A tube of glass of refractive index 1.65 is **surrounded** by glass of refractive index 1.51. Calculate the **critical angle** for light travelling along the tube and incident on the boundary between the glasses.

11. Calculate the **number** of photons per second incident on a spot of light made by a 1.2 watt ruby laser with a wavelength of 694 nm.

12. A 15 g piece of ice, at its melting point, is floated in a beaker containing 200 cm^3 of water at 20^{o}C. Assuming that the ice is totally melted by heat from the water and that the water loses no heat to the surroundings, calculate the **temperature** to which the water falls (to the nearest degree). (Remember to take into account the heat needed to warm up the water from the **melted** ice).

Exercise 31

1. Light of wavelength 5.1×10^{-7} m shines on a metal, for which at least 2.9×10^{-19} J of energy is required to eject a photoelectron.
   By calculating the energy of a photon of the light, show whether or not it **could eject** electrons from the metal.

2. A radioisotope emits 96 million beta particles in 10 minutes. Calculate the **activity** of the source.

3. The **corrected** count rate measured for a radioactive substance falls from 14000 counts per minute to 875 counts per minute in 24 minutes.
   What is the **half-life** of the radioactive substance?

4. The corrected count rate from a radioactive source is found to be 6600 c.p.m. A thick piece of paper is placed between the source and counter and the count in one minute falls to 1250. A few millimetres of aluminium now replaces the paper and the count is measured at 1270 for one minute.
   What **two** types of radiation are being emitted by the source?
   What **absorber** could reduce the corrected count rate to almost **zero?**

5. What is the **time** for one cycle of an alternating voltage with a frequency of 60 hertz? What **term** is used for this time?

6. Calculate the value of the **output voltage** in a differential amplifier where: $V_1 = 3.5$ volts, $V_2 = 4.5$ volts, $R_f = R_3 = 100\ k\Omega$, $R_1 = R_2 = 10\ k\Omega$.
   (The power supply for the amplifier is 15-0-15 volts).

7. Calculate the **weight** of 1.25 litres of mercury. (1 litre= 1000 cm^3).
   What volume of **water** would weigh the same?

8. An experiment to measure the density of air gave this data:
   Mass of air = (1.5 $^+/_-$ 0.1) g ; Volume of air = (1200 $^+/_-$ 10) cm^3
   Calculate the **best estimate** of the **density** of air and its **absolute** error.

9. In a certain atom, an electron makes a transition from an energy level of -2.42×10^{-19} J to a lower level of -21.8×10^{-19} J.
   Calculate the **wavelength** of the photon emitted from the atom.

10. An 80 kg man sits on the blunt end of a drawing pin which has an area of 0.7 cm^2. Calculate the **pressure** (in pascals) exerted by the pin on the man.

11. In the 'equation of motion' $\mathbf{s = ut + {}^1/_2\, at^2}$, which **quantities** are represented by the terms '**ut**' and '$\mathbf{{}^1/_2\, at^2}$'?

12. A car accelerates along a straight road from 10 ms^{-1} to 20 ms^{-1} in 5 seconds.
    How **far** does it travel during this period of acceleration?

Exercise 32

1. An 80 kg man absorbs total energy of 16 mJ from a radioactive source over a period of 15 hours. Calculate the **absorbed dose** which the man receives in micrograys and the **absorbed dose rate** in micrograys per hour.

2. A 20 g bullet, travelling at 400 ms^{-1}, strikes a sand bag and becomes embedded to a depth of 20 cm. Calculate the **average** stopping **force** acting on the bullet.

3. A car, which was travelling at 20 ms^{-1}, accelerates in a straight line for 5 s at 2 ms^{-2} . Calculate its **average speed** and the extra **distance** moved?

4. In a nuclear **fission** reaction, mass totalling 3.6 x 10^{-28} kg is converted to energy. Calculate the **energy** released in **joules per fission** and the **number** of fissions per second needed to produce 50 MW of power.

5. What **fraction** of the original activity of a radioisotope remains after **four** half-lives have elapsed?

6. If a beta source has an activity of 185 kBq, approximately how **many** beta particles would be emitted during an experiment lasting for 15 minutes?

7. Estimate the **minimum power** developed by a 60 kg girl's **legs** in running up a 12 metre high flight of stairs in 15 seconds.

8. A ray of light travelling through **water** (n = 1.33) is incident on a block of glass at 53º to the normal. If its refracted angle in the glass is 43º to the normal, find the **refractive index** of the glass.

9. Given a table of data for the **count rate** at various distances from a **point** source of gamma radiation, what **graph** should be drawn to illustrate the relationship between count rate and distance? How would a **systematic error** in the measurement of the count rate (such as including the background count) 'show up' on the graph?

10. A model boat has a mass of 2.5 kg. Calculate the **volume**, in litres, of pond water it would **displace** when afloat. (Density of water = 1 g/cm^3).

11. A driver switches on her car's headlamps whilst the engine is off. Each lamp draws 2 amps from the battery which has an e.m.f. of 12 volts as measured by the car's voltmeter. The potential difference across the terminals of the battery falls to 11.2 volts. What is the value of the battery's **internal resistance**?

12. Two 5000 µF capacitors are connected in **parallel**. They are fully charged when 120 mC of charge in **total** is delivered to the combined capacitors from a 12 V battery. Calculate the **capacitance** of the combination.

Exercise 33

1. An empty room measures 5m x 4m x 3m. Calculate the **mass** of air in the room. (Density of air = 1.23 kgm^{-3}).

2. The average dose equivalent for a person in Scotland due to background radiation over a whole year is about 2 mSv.
   What is the person's **dose equivalent rate** in microsieverts per week?

3. If the quality factor is **1** for beta particle radiation and **20** for alpha radiation, calculate the **dose equivalent rate** for a person who receives, over a period of 6 hours, 20 µGy of beta radiation and 5 µGy of alpha radiation.

4. Which quantities are found from the **gradients** of (a) velocity-time graphs and (b) displacement-time graphs?

5. In a **fusion** reaction between two light nuclei, 6.3 x 10^{-13} joules of energy is released. Calculate the **mass** which has been changed to energy.

6. At what **speed** does light travel through water of refractive index 1.33?

7. Calculate the minimum **time** for a radio wave to travel to and from a geostationary satellite, in orbit **36000 km** above the Earth's surface.

8. A stone, thrown vertically upwards from the very edge of a cliff at 10 ms^{-1}, reaches the foot of the cliff after 5 seconds. What is the **height** of the cliff?

9. A helicopter is carrying a car on the end of a cable at a **steady** speed and height. The tension in the cable is 3000 newtons and the cable makes an angle of 15^{o} with the vertical. Calculate the **weight** of the car and the **force** of air resistance acting on it (to **two** significant figures).

10. A 5 kg mass is pulled up a 30^{o}, **frictionless** slope by a 4 kg mass hanging vertically from a light cord. The cord joins the two masses and passes round a **frictionless** pulley which is at the top of the slope.
    Calculate the **acceleration** of this system. ('g' = 10 Nkg^{-1}).

11. A strobe photograph of an accelerating trolley has **successive** images of a point on the trolley which are 1.0 cm, 2.0 cm, 3.0 cm and 4.0 cm apart.
    If the photo is **half of life size** and the trolley is found to have an acceleration of 2.0 ms^{-2}, calculate the **flash rate** of the stroboscope used for the photo.

12. The mains electricity has been reduced from 240 V a.c. to 230 V a.c. Assuming that the resistance of the element of an electric fire does not change with temperature, calculate the percentage **drop** in the **power output** from the element.

Exercise 34

1. Calculate the **wavelength** and **period** of microwaves which have a frequency of 10^{11} Hz, when travelling through the air.

2. A woman of mass 60 kg absorbs a total of 3 joules of energy from radiation due to a nuclear accident. What is the value of her **absorbed dose**?

3. 200 µGy of radiation dose from thermal neutrons has the **same** dose equivalent as 30 µGy of alpha particle radiation. If the **quality factor** for alpha radiation is **20**, what is its value for thermal neutrons?

4. A rope is stretched horizontally between two trees. A tightrope walker stops in the middle and stands on one leg. Each of the ropes makes an angle of **15º** to the horizontal and the man weighs **700 N**.

   Calculate the **tension** in the rope.

5. A car, mass 1500 kg, travelling **east** at 24 ms^{-1}, collides 'head on' with a 2000 kg car travelling **west** at 18 ms^{-1} and they **lock** together. Describe what happens to the **motion** of the cars as a result of the collision and calculate the total **loss** of **kinetic energy**.

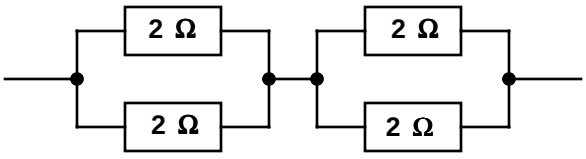
6. If, for a certain metal, the energy required for a photon to eject an electron is 6.2×10^{-19} J, what is the **longest** wavelength of light that could achieve this?

7. Express 2000 cm^2 in **square metres** and 2000 cm^3 in **cubic metres**.

8. Draw the circuit symbol for a semiconductor **diode** and indicate the direction of **electron** flow.

9. How does the **upthrust** of the water alter when a ship sails up river from the salty sea into increasingly fresh water and what happens to the **depth** to which the hull sinks below the surface of the water? (Assume the ship's weight remains constant).

10. What is the total resistance when two **2 Ω** resistors, in **parallel**, are themselves in **series** with another pair of **parallel 2 Ω** resistors?



11. What is the **resistance** of a toaster element which produces power of 300 watts when operated from 240 V a.c.?

12. A rechargeable cell is labelled **1.2 V 1.2 Ah**. How much **charge** does this rating suggest would be required to fully recharge a 'flat' cell?

Exercise 35

1. The mass of water collected for a given heat input for a certain distillation apparatus is measured a number of times. The measurements are, in grams:

   490, 510, 483, 425, 550, 573, 482, 505, 449, 523.

   What are the **best estimate** of the true value of the water's mass and the **random erro**r is this value?

2. A steel ball is dropped from rest and timed electronically over 40 cm. If the measured time is 0.29 seconds, what value does this give for **'g'**?

3. A cell of e.m.f. 1.55 volts delivers a current of 200 mA to an external load of 7 Ω. What is the value of the cell's **internal resistance** and what would the **current** delivered be if the load was changed to 14 Ω?

4. When 33 mm of lead is placed between a gamma source and a detector, the count rate falls from 1550 c.p.m. to 220 c.p.m. If the background count is 30 c.p.m., calculate the **half value thickness** of the lead.

5. What is the **minimum power** which a man's legs must develop to push his broken down car at a steady speed of 80 cms^{-1} against a frictional resistance of 400 N?

6. During a car crash, the driver's body, mass 65 kg, is brought to rest from a speed of 10 ms^{-1} by the seat belt. If, because of the crumpling of the car's front and the stretching of the seat belt, the driver's body moves forward by 75 cm before coming to rest, what **average force** acts on it whilst it is stopping?

7. Which **unit** could be expressed otherwise as an '**ampere squared - ohm**'?

8. A dam is 600 m above sea level. 4000 kg of water per second runs through pipes from the dam to a hydroelectric power station which is 100 m above sea level. How many **joules** of potential energy are converted to other forms of energy every second?

9. An a.c. voltage supply is displayed on the screen of a C.R.O. which has its **Y-gain** control set at 5 V/cm. If the peak to peak measurement of the trace is 6.8 cm, calculate the value of the **r.m.s. voltage** of the supply.

10. Assuming its resistance is constant, by what **factor** does the power dissipated in a resistor **increase** if the p.d. across it doubles?

11. What would the **upthrust** of the water be on a 70 kg swimmer in a pool on a **Mars** base in the 21st century?

12. What **fraction** of a radioisotope's original activity remains after 5 half lives?

Exercise 36

1. A glass prism is made in the shape of an isosceles triangle with a 90º angle. A ray of light enters the prism at 90º to a short side face and is incident on the face of the longest side of the triangle. Show that the ray is **totally internally reflected** at the face, if the refractive index of the glass is 1.52.

2. The sodium D-lines are caused by electrons in excited atoms making transitions between energy levels which release, on average, 3.36×10^{-19} J of energy. Calculate the average **wavelength** of the emitted radiation.

3. Calculate the **energy** gained by an electron accelerated by a p.d. of **60 kV** in an X-ray machine.

4. What **speed** is reached by an electron, accelerated from rest by a potential difference of 160 volts?

5. What energy change **always** happens when an electric current flows through a resistance?

6. In a series circuit of a 9 V battery, a 1750 Ω resistor and a 2200 µF capacitor, calculate the **charge** on the capacitor plates and the charging **current** at the instant when the **p.d.** across the **resistor** is 5.2 V.

7. A metre bridge has an unknown resistance '**X**' in one gap and a standard resistor of **20.0 Ω** in the other gap. Balance is obtained at 42.5 cm from the end of the wire at the '**X**' end. Calculate the value of the resistance of '**X**'.

8. If a metre bridge has a reading error of **+/- 1 mm**, what is the **percentage error** in the calculated value of an unknown resistance if the balance point is

   (a) **1 cm** and (b) **50 cm** from one end of the wire?

9. A car of mass 1500 kg, travelling at 40 ms^{-1}, is slowed by the combined effect of its brakes and air resistance to half this speed. If 95 % of the work was done by the brakes over a distance of 150 metres, what was the **average force** applied by the brakes?

10. A gas in a rigid flask has a pressure of 9×10^4 Pa. Its temperature is 9º C. Calculate the **celsius temperature** to which the flask should be heated for its pressure to increase to 1.5×10^5 Pa.

11. The density of chloroform is 1.6 g/cm^3. Express this value in **kg m^{-3}** and **grams per litre**. What **volume** of chloroform would **weigh** 4 newtons?

12. Which **quantities** are given by the **gradients** of (a) a charge-time graph and (b) a charge-voltage graph for a charging capacitor?

Exercise 37

1. A stone is thrown vertically upwards at 15 ms^{-1}. After what **time** is the stone 10 m **above** its starting point and **falling**? (take g = 10 ms^{-2}.)

2. Which **two** criteria must be met for a line graph to indicate **direct proportionality** between two quantities?

3. Two men, each exerting a horizontal push of 500 newtons, accelerate a broken-down car from rest at 0.3 ms^{-2} along a flat, horizontal road. If the car's weight is 13720 newtons, calculate the total value of the **frictional forces** acting on the car.

4. A carpet cleaning machine holds 42 litres of water. It has a 3 kW heater which cuts out at 70ºC. What is the **minimum time** that the heater would require to heat a full load of water to 70ºC from 15ºC and why, in practice, would it take much **longer**? (c for water = 4180 $Jkg^{-1}K^{-1}$).

5. A 2.3 kW kettle fails to switch off when the water reaches boiling point. If there are 1.1 litres of water in the kettle at this time, how **much** will remain after 10 minutes?

6. What maximum r.m.s. **current** flows through the fuse in the plug of a two bar electric fire if each element has a rating of 1 kW and, in addition, the fire has three decorative 60 W lamps? Assume the mains supply is 240 volts r.m.s.

7. What is the **tension** in a crane's cable if it is lifting a 2500 kg mass **vertically** with an **upwards** acceleration of 0.5 ms^{-2}?

8. A swimmer dives vertically from the 6 metre board and, in so doing, his centre of gravity reaches a height of 1.5 metres above the board. Find the swimmer's approximate **speed** on hitting the water.

9. A 2200 µF capacitor is charged by a **steady current** of 1 mA from a 9 volt battery. How **long** will the capacitor take to become fully charged (to the nearest second)?

10. What is the maximum **speed** reached by electrons accelerated from **rest** by a voltage of 2.6 kilovolts?

11. Radon-222 has a half-life of 92 hours. How **long** would it take for the activity of a sample of the gas to be reduced to about **3%** of its initial value?

12. In a radioactivity experiment, the demonstrator received a dose of 30 µGy of gamma radiation. If the experiment lasted 15 minutes and the 'quality factor' for gamma radiation is unity, calculate the **dose equivalent rate** received by the demonstrator in microsieverts per hour.

Exercise 38

1. If a load of clothes from a washing machine contains 1500 g of water, estimate the **time** needed for a tumble dryer (producing 2 kW of heat power) to totally dry the clothes.

2. What **two** resistances, measuring **16 Ω** when connected in **series**, make a total resistance of **3 Ω** when connected in parallel?

3. In a **fission** of a uranium-235 nucleus, the energy released is 3.33×10^{-11} J. Calculate the mass lost in the fission.

4. A lamp, which can be taken to be a point source of light, produces an intensity of illumination of 18 Wm^{-2} at a distance of 3 metres. Calculate the **intensity** at (a) **2 m** and (b) **5 m** from the lamp.
   How **far** from the lamp would the intensity be 72 Wm^{-2}?

5. A laser has a power of 2.5 mW. Its light is of wavelength 515 nm. Approximately how **many** photons per second are emitted in the laser beam?

6. How many **protons** and **neutrons** are in the nuclei of these isotopes:
   (a) uranium-235, (b) carbon-12, (c) lead-214?

7. In measuring the resistance of a resistor by the ammeter-voltmeter method, a pupil makes these measurements with digital meters:
   voltage = (1.52 +/- 0.01) volts; current = (2.3 +/- 0.1) milliamps.
   Use these values to obtain a value for the **resistance** and its **absolute** error.

8. How much **charge** flows through a resistance if 10 joules of energy is transferred from electricity to other forms and the p.d. across the resistor is 4 volts?

9. How much gravitational **potential energy** is lost by a 2 kg steel puck sliding from rest for a distance of 2 metres down a slope which is at 35º to the horizontal and what **speed** would it attain if frictional forces were negligible?

10. A 3 kg mass on a string is held **at rest** at a certain angle to the vertical by a horizontal force of 21 newtons. Find the **angle** and the string's **tension**?
    ('g' = 10 Nkg^{-1}).

11. A hockey ball is propelled at a free hit with a speed of 20 ms^{-1}. The ball's mass is 160 g and the time of contact between the stick and ball is 2 ms. Calculate the **average** force exerted on the ball by the stick.

12. What is the **minimum** time it would take a 59 kg boy to run up a 20 metre high flight of stairs if his legs can develop a power of 390 watts?

Exercise 39

1. Two forces of 40 N and 50 N act on a mass and add to give a resultant force of 74 N. By trigonometry or scale vector diagram, find the **angle** between the forces.

2. Calculate the **total force** which the atmosphere exerts on the surface of the water in a swimming pool at sea level which measures 50 m by 25 m.

3. An electric motor is used to raise a 2 kg mass at a speed of 10 cms^{-1}.
The **input** power to the motor is found from the voltage of its supply (5.5 V) and the current drawn from the supply (0.48 A).
Calculate the **efficiency** of the operation.

4. For a cell of e.m.f. '**E**' and internal resistance '**r**', delivering current '**I**' to a load of resistance '**R**', show that: $\mathbf{R = \frac{E}{I} - r}$. Sketch the graph '**R** against $\mathbf{\frac{1}{I}}$'.
Which **quantities** are found from the graph's

   (a) **gradient** and (b) **intercept** on the '**R**' axis?

5. In a metre bridge, if the standard resistor is 100 Ω and the 'unknown' resistor turns out to be 134 Ω, at what **point** on the wire would **balance** be found?

6. An op-amp, connected in the 'inverting' mode, has R_f = 100 kΩ and R_1 = 5 kΩ. Find the **gain** of the amplifier and the **output voltage** when the input is (a) **400 mV** and (b) **-2V** (Assume the supply voltage is 15-0-15 V).

7. A light emitting diode (LED) is rated at 2 V 30 mA. Calculate the value of the **series resistor** required to operate it from a 6 volt supply.

8. In a voltage divider consisting of a **5 kΩ resistor** and a **10 kΩ rheostat**, what **range of voltages** would be available across the rheostat if the supply voltage was 12 V?

9. A 10000 μF capacitor is charged from a 9 volt battery at a **steady** current of 5 mA by the gradual reduction in resistance of a series rheostat. Calculate the **final charge** on the capacitor plates, the **time** taken to fully charge it and the **initial** value of the rheostat's **resistance**.

10. With a **calculator**, find the value of $\mathbf{2.5 \times 10^4 \div 10^{-3}}$ and $\mathbf{10^{-5} / (2 \times 10^{-6})}$

11. The **areas** under which **graphs** would calculate, for an object,
   (a) **impulse** (b) **displacement** (c) **change of velocity**?

12. A sound has a wavelength of 60 cm in air where its speed is 340 ms^{-1}.
What would the **wavelength** of the sound become if it passed into water, where its speed is 1500 ms^{-1}?

Exercise 40

1. Ultra-violet radiation, with a frequency of 3.1×10^{16} Hz, ejects an electron from a metal plate with kinetic energy of 5.6×10^{-18} J. Calculate the **energy** that was needed just to eject the electron from the metal and the **minimum frequency** of radiation which *could* have ejected the electron.

2. Radon-220 gas is radioactive with a half-life of 55 seconds. How **long** would it take the activity of a sample of this gas to fall to about **3%** of its original value?

3. A diffraction grating has 5000 lines per cm. In the **first** order spectrum of cadmium, at what **angle** would the red line be found? (λ = 644 nm)

4. A thin ray of monochromatic light enters a block of pure ice at an angle of 42.0^{o} to the normal from the air. If the refracted angle in the ice is 30.7^{o}, calculate the **critical angle** for ice?

5. An isotope of uranium has an atomic number of 92 and a mass number of 238. It is radioactive and emits alpha particles, forming a daughter isotope which is also unstable, emitting betas. What are the **atomic** and **mass numbers** of the daughter and granddaughter? **Identify** the two elements.

6. A rechargeable cell has an e.m.f. of 1.2 volts and an internal resistance of 0.2 Ω. Calculate the **power dissipated** in the internal resistance when the cell is delivering current to a 0.8 Ω load.

7. How would four resistors, (**2 Ω**, **3 Ω**, **6 Ω** and **10 Ω**) be connected to make a **total** resistance of **11 Ω**?

8. An op-amp in the inverting mode has an output voltage of -300 mV for an input of 20 mV. If R_1 = 10 kΩ, what is the **resistance** of the feedback resistor?

9. A 10 Ω resistor has a **power** rating of 1 watt.
   Calculate the **maximum current** the resistor can carry.

10. A girl weighs 539 newtons on Earth. What would be her **mass** and **weight** on a planet where the gravitational field strength at the surface is 14 Nkg^{-1}?

11. A boy decides to estimate the height of a cliff by timing the fall of a stone into the sea below. After several repeats, he arrives at a figure for the time of fall of (4.2 ± 0.3) seconds. Use his figures to calculate the best estimate of the **height** of the cliff and its **absolute error**.

12. A man of mass 80 kg 'feels' that he weighs 824 N when a lift is moving upwards at 1 ms^{-1} and getting faster. If his apparent weight does not change, calculate the lift's **speed** exactly one second later.

Exercise 41

1. An op-amp in the differential mode has R_1 = 20 kΩ, R_2 = 10 kΩ and R_3 = 40 kΩ. State the **value** of R_f and calculate the **output voltage** when V_1 and V_2 are 100 mV and 140 mV respectively.

2. In a series circuit of 10 μF capacitor and 1 MΩ resistor, the capacitor is charged from a 12 V battery. What is the value of the **maximum current** during the charging and the **energy stored** in the fully charged capacitor?

3. In a spectrometer which has a diffraction grating with 6000 lines per cm, a green line in the **first** order spectrum of mercury vapour is found when the telescope is at 19.1º from its central position. What is the **wavelength** of the light which creates this line?

4. The radioisotope cobalt-60 has a half life of 5.3 years. What **percentage** of the original activity of a cobalt-60 source, purchased in 1974, will remain by the turn of the century?

5. A ball, of mass 450 g, travelling at 6 ms^{-1}, is given a kick which sends it in the opposite direction at **double** the speed. Calculate the **impulse** of the kick on the ball and state what **other** information is needed to allow the average **force** of the kick to be calculated.

6. A cyclist and her bicycle together have a mass of 90 kg. If she accelerates from rest at 2 ms^{-2} for 3 seconds, calculate the **kinetic energy** gained and the **minimum average power** developed by the cyclist's muscles.

7. Use a **calculator** to find the value of $\mathbf{10^5 \times 2 \times 10^{-4}}$ and $\mathbf{10^{-4} \times 0.5 \times 10^6}$

8. What **pressure**, in pascals, does a 75 kg man exert, standing still on the ice of a frozen pond, if his feet make contact with 500 cm^2 of the ice?

9. If the metre stick on a metre bridge can be read to the nearest **millimetre**, and the bridge balances at 2.0 cm from one end of the wire, what would be the **absolute** error in the calculated value of 62 Ω for the resistance being measured?

10. A 1.7 kg trolley is at rest on a 21º slope. Find the **force** acting parallel to the slope to hold the trolley at rest .

11. What minimum rocket **thrust** would be required to enable a 4510 kg spacecraft to lift off from the surface of Mars with a vertical acceleration of 2.5 ms^{-2}?

12. A cell of e.m.f. 1.5 volts delivers 300 mA to a 4 Ω load. Calculate the **internal resistance** of the cell and the **current** when the load is 2 Ω.

Exercise 42

1. A radioactive source with a half life of 120 days contains 2×10^{20} radioactive atoms. How **many** of the **original** radioactive atoms remain after 480 days?

2. A medical laser supplies a maximum of 350 joules of light in a burst of duration 1 ms on a spot of radius 2 mm. Calculate the **power per unit area** of the beam in **GWm^{-2}**. (1 GW = 10^9 W)

3. An old unit for stating the **activity** of a radioactive source was the **curie (Ci)**; 1 Ci = 3.7×10^{10} Bq. Convert 5 µCi into **kBq**.

4. For school pupils, the whole body dose limit of radioactivity for a year is set at 500 µSv. What is the **maximum** quantity of radiation energy which a 60 kg pupil could absorb over a **year** and be **within** this limit?

5. The dose equivalent rate from a strontium-90 beta source, at one metre distance, is about 1.3 μSvh^{-1}. A teacher demonstrates an experiment using the source to six different classes for twenty minutes each. On average, he is one metre from the source. Calculate the **total dose** received by the teacher from the source.

6. The dose equivalent rate from a gamma source is found to be 600 μSvh^{-1} at a distance of 2 metres from the source. Assuming it to be effectively a **point source**, what would be the **dose equivalent rates** at 1 m, 4 m and 10 m?

7. A capacitor is charged from a battery of e.m.f. 9.0 volts by a **steady** charging current of 1.8 mA. The charging takes 25 seconds. Calculate the value of the **capacitance** in microfarads and the **total energy** stored.

8. Three resistors, values **10 Ω**, **15 Ω** and **30 Ω** are connected so as to make a **total** resistance of 20 Ω. Sketch the **arrangement** of the resistors.

9. A 2.2 kΩ resistor and a 4.7 kΩ resistor form a voltage divider across a 12 volt battery. Calculate the **voltage** across the **larger** resistor.

10. Given a table of data with pairs of values for the **kinetic energy** and **speed** of a moving object, which **graph** would be drawn to show the mathematical relationship between the two quantities, by a straight line through the origin?

11. What change in **kelvin** temperature has occurred if a substance is heated from - 29ºC to 128ºC?

12. A gas, at -1ºC and 1.01×10^5 Pa, is heated in a rigid container until its pressure has increased by 50%. What is its new **temperature**?

Exercise 43

1. The refractive index of glass for light of wavelength 452 nm in air is 1.58. What are the **speed** and **wavelength** of the light in the **glass**?

2. The critical angle for perspex is 42.5º. Calculate its **refractive index** (to 3 significant figures).

3. An optical fibre has a refractive index of 1.52 and is surrounded by a cladding material, index 1.43. Calculate the **minimum** angle for which light can be **totally internally reflected** at the boundary between the two materials.

4. A ball is kicked at 35 ms^{-1} at an angle of 40º above the horizontal from the edge of a cliff. How **far** is it from the edge of the cliff at the instant it is once again **level** with the cliff top?

5. The driver of a car, travelling in a straight line at 40 ms^{-1}, slams on the brakes and locks the wheels. The car skids to a halt in a distance of 200 metres. Calculate the average **stopping force** and the **work done** by friction in stopping the car, if the car's **weight** is 9.8 kN

6. An op-amp in the inverting mode has R_f = 100 kΩ and R_1 = 20 kΩ. If the power supply is 15 volts and saturation occurs at 1.5 V less than the supply, what is the **maximum** r.m.s. value of an alternating **voltage** which could be applied to the input without distortion occurring in the output?

7. A rechargeable cell is labelled 1.2V0.5Ah. How **long** do these figures suggest it would take to fully charge the cell with a **steady** current of 100 mA?

8. Calculate the **heat** needed to raise the temperature of a 2.5 kg block of ice to its melting point, if it is stored in a freezer at -18ºC. (c_{ice} = 2.1 $kJkg^{-1}K^{-1}$).

9. A radioactive source emits approximately 850 million betas in one hour. Calculate its **activity** in kilobecquerels.

10. A gamma ray source gives a dose equivalent rate of 1600 $mSvh^{-1}$ at a distance of 1 metre. A **one metre wide** tank of water is introduced between the source and detector and the dose equivalent rate is found to be reduced to 50 $mSvh^{-1}$. What is the **half value thickness** of water for gamma rays?

11. In a laboratory where the background count is 25 counts per minute (c.p.m.), the **uncorrected** count rate from a radioisotope falls from 960 c.p.m. to 54 c.p.m. over 1 hour 15 minutes. What is the **half-life** of the radioisotope?

12. What is the **quality factor** for thermal neutrons if an 80 kg man absorbs 6.4 mJ of energy and thus has received a **dose equivalent** of 240 µSv?

Exercise 44

1. In a nuclear fission, the total mass of the particles **before** the fission is 236.0021 u and the total mass **after** is 235.7780 u. Calculate the **energy** released in the fission. (Refer to **data** for the value of '**u**').

2. An electron makes a transition from a high energy level to the ground state in an atom. Its energy in the high level is - 5.2 x 10^{-19} J and, in the ground state, it is -24.6 x 10^{-19} J. What is the **wavelength** of the photon emitted?

3. In a light emitting diode (LED), an electron combines with a hole to produce a photon with a wavelength 680 nm.

   Calculate the **energy** released by the re-combination.

4. A pellet leaves an air rifle with a velocity of 120 ms^{-1} at an angle of 34º above the horizontal. Ignoring the effects of air resistance, how **high** would the pellet reach above the rifle?

5. A cyclist is pedalling along a horizontal road at a steady speed of 5 ms^{-1}. She experiences a total frictional resistance of 30 N. Calculate the minimum **power** generated by the cyclist's legs.

6. A puck slides down a frictionless, 40 cm high ramp which is curved so that the puck leaves the end horizontally. The end is at the edge of an 80 cm high table. How **far** from the foot of the table does the marble land. (Ignore frictional effects of air resistance).

7. At what **angle** to each other are two forces of values 3.0 N and 4.0 N if they combine to make a **resultant** force of magnitude 6.1 N?

8. A 40 g block of ice at 0ºC, placed in a beaker of water at 25ºC, melts and the water's temperature drops to 8ºC. Assuming no heat loss to the surroundings, what **volume** of water **was** in the cup?

9. A 1 kg mass is hanging from a newton balance in an **upward** moving lift. What is the lift's **motion** when the balance reads 10.3 N?

10. How would four resistors, **2Ω**, **3 Ω**, **5 Ω** and **7.5 Ω** be **connected** to make a total resistance of **10 Ω**?

11. Light enters a block of glass under water and makes angles to the normal of 45º and 36º in the water and glass respectively. Calculate the **refractive index** of the glass and its **critical angle under water**.

12. The half-life of a radioisotope is 3.7 days. How **long** would it take for the **activity** of a sample of the isotope to fall to one-sixty fourth of its original value?

Exercise 45

1. A radioactive source has an activity of 1.5 MBq. How many **decays** would occur in one hour?

2. The dose equivalent rate from a '**point**' gamma source is 0.10 μSvh^{-1} at a distance of 1 m. What would the **rate** be at (a) 0.5 m and (b) 2 m?

3. The **half value thickness** for lead is 11 mm for gamma rays. If the dose equivalent rate at a certain distance from a gamma source is 2.0 μSvh^{-1}, what **thickness** of lead would need to be introduced to **reduce** the dose equivalent rate to 0.25 μSvh^{-1}?

4. In a particular nuclear fusion reaction, 2.79×10^{-12} J of energy is released. Calculate the **mass** lost in the reaction.

5. The blue line in the cadmium vapour emission spectrum is viewed in the **2nd order** with a spectrometer telescope at 28.7^{o} from the central position. The grating has 5000 lines per cm.
   Calculate the **wavelength** of the blue light and the 1st order **angle** of view .

6. 2.8 cm microwaves are diffracted through two narrow slits in a metal screen and form an interference pattern. A detector probe is positioned at 20.1 cm and 29.9 cm respectively from the **centre** of each slit . Which would be detected at that point by the probe, a **maximum** or **minimum** signal? Why?

7. At a distance from a point source of monochromatic light, the intensity is 3 Wm^{-2}. If the light's wavelength is 620 nm, calculate the **number** of photons incident per **second** on each square centimetre of a screen at that distance.

8. Light of wavelength 5.9×10^{-7} m, travelling through water, enters a block of glass (n = 1.60). What are its **wavelength** and **frequency** in the glass?

9. A Wheatstone bridge is put out of balance when **one** of the resistors changes from 8500 Ω to 8510 Ω. The bridge meter reads 2.4 mA. The resistor's value continues to increase. What would it be when the ammeter reads **6.0 mA**?

10. A certain characteristic of the charging of a capacitor can be estimated by multiplying together the capacitance and the circuit resistance. Which **quantity** is found by this making this calculation?

11. A block of wood of mass 1.6 kg **just** starts to slide down a smooth slope when the angle is 35^{o}. What **friction force** acts between the wood and the slope just as it starts to slide?

12. In a cricket match, a batsman scores two runs. Calculate (a) the **distance** run and (b) his **final displacement**. (Length of wicket = 22 yards).

Exercise 46

1. 2.8 cm microwaves are diffracted through two narrow slits in a metal screen and form an interference pattern. A detector probe is positioned so that it is 14.5 cm from the centre of one slit. A **maximum** reading is obtained on the probe's meter. Give **one** possible figure for the probe's distance from the centre of the second slit.

2. If the **mass** of the Sun is decreasing at the rate of 4 million tonnes per second, calculate the energy released every **day**.

3. If one gram of carbon from a living tree has an **activity** of 15 decays per minute due to the radioisotope carbon-14 which has a half-life of 5600 years, what **count rate** per gram would be expected from a wooden artefact made in 3500 B.C.?

4. A photon creates an electron-positron pair and is annihilated in the process. If both particles have mass of 9.11×10^{-31} kg, calculate the **minimum** frequency which a photon must have to undergo this transformation.

5. One of the yellow sodium D-lines, wavelength 589 nm, is viewed in the **first** order spectrum at an angle of 20.7^{o} from the centre. How many **lines per centimetre** does the spectrometer's diffraction grating have?

6. A student measures the mass of a container of water with a two pan balance. He decides to measure the mass a number of times and obtains these readings, in grams: 121.8, 123.8, 122.7, 122.5, 121.9, 124.0, 122.0. What should he state as the **best estimate** of the true value of the mass and its random **error**?

7. What would a voltmeter read across the terminals of a battery with an internal resistance of 2 Ω delivering a current of 500 mA, if it reads 9.3 V on **open** circuit? What would the **current** be if the t.p.d. was 9.0 V?

8. Calculate the **energy stored** in a capacitor charged to 12 volts which stores 0.27 J when charged to 9 volts.

9. Calculate the **buoyancy force** acting on a 25 cm^3 lump of iron (ρ = 7870 kgm^{-3}) floating in a beaker of mercury (ρ = 13600 kgm^{-3}), and the **volume** of mercury displaced.

10. By what name is the unit **'amp-ohm'** better known?

11. Given data consisting of pairs of displacement-time measurements for an object accelerating uniformly from rest, what **graph** could be constructed using the measurements which would be a straight line through the origin?

12. Calculate the **acceleration** of a car which, from 20 ms^{-1}, travels a **further** 78 metres in a straight line in 3 seconds.

Exercise 47

1. A man of mass 80 kg receives a radiation dose consisting of 20 mJ of energy from beta particles (Q = 1) and 5 mJ from alpha particles (Q = 20).

   Calculate his **total dose equivalent** in microsieverts.

2. A Geiger tube detects 4200 gamma rays per minute from a cobalt-60 source. 32 mm of lead is placed between the source and Geiger tube and the corrected count rate falls to 520 counts per minute. What value do these figures suggest for the **half-value thickness** of lead?

3. In a laser, 2.5×10^{15} photons per second are emitted in the beam. What is the **wavelength** of the light if its beam power is 1 mW?

4. A photon of wavelength 580 nm falls on a clean metal surface and ejects a photoelectron which has kinetic energy of 2.2×10^{-20} J.

   Calculate the **threshold frequency** for the metal.

5. At what **angle** would the **second order** red line in the emission spectrum of cadmium vapour be observed if the spectrometer's grating has 6000 lines per cm? (λ_{red} = 644 nm)

6. Using a grating with 7500 lines per cm, what would the **angular separation** be of the sodium D-lines in the **second** order spectrum? (λ = 589.0 nm; 589.6 nm)

7. The t.p.d. across a battery of e.m.f. 12 volts falls to 10 volts when it delivers current to an **external** load of 10 Ω. Calculate the **internal resistance** and the **power dissipated** in it.

8. What value of **resistance** would be connected in **parallel** to a 2.4 kΩ resistor to make a **total** resistance of 800 Ω?

9. Two **identical** capacitors are connected in series and charged from a 12 volt battery. The total energy stored is 0.36 J. What is the value of each capacitor?

10. An op amp in the inverting mode has R_f/R_1 = 100 x. What would the **frequencies** of the **output** signals be for these input signals?

    (a) 50 Hz (b) 100 Hz (c) 2 kHz

11. The engines of a hovercraft, mass 12 tonnes, travelling in a straight line at a constant speed of 15 ms^{-1}, develop a forward thrust of 30 kN.

    What is the total magnitude of the frictional **forces** acting on the vessel?

12. A 500 g hammer head, falling from a height of 50 cm, strikes a nail and drives it 1 cm into a block of wood. Calculate the **average resistive force** exerted by the wood on the nail.

Exercise 48

1. A 2 kg block is pulled up a 30^o slope by a 20 N force. The block has an acceleration of 2.5 ms^{-2}. What **friction force** exists between the block and slope (magnitude and direction)? ('g' = 10 Nkg^{-1}).

2. A car of mass 1500 kg, travelling at 15 ms^{-1}, collides 'head on' with a second car, mass 1000 kg, which has a speed of 16.5 ms^{-1} in the opposite direction. Find the **speed** and **direction** of the cars immediately **after** the collision, assuming that they remain locked together.

3. In a water rocket, what is the **reaction** to the force exerted by the compressed air on the water?

4. When a ship sails down river towards the open sea, what happens to **size** of the **upthrust** exerted by the water on the ship and to the **depth** to which it sinks in the water? (Assume that the ship's weight does not change).

5. How much **kinetic energy** is gained by an electron accelerated from rest by a potential difference of 215 volts? What is its **final speed**?

6. What is the **approximate** resistance of **2 Ω** in **parallel** with **2 kΩ**?

7. Two capacitors in **parallel** are charged from a 9.0 volt battery. One of the capacitors acquires a charge of 72 µC on its plates.
   What is the **value** of its capacitance?

8. An op amp in the **inverting** mode has an output voltage of 4.8 V with R_f = 50 kΩ and R_1 = 5 kΩ. What is the **input voltage** to the amp?

9. Complete this statement for an object in a fluid (liquid or gas):
   upthrust = _ _ _ _ _ _ **of fluid** _ _ _ _ _ _ _ _ _ _

   Is it true for a floating object, a sunken object or both?

10. The dose equivalent rate from a **point** source of gamma radiation is 4 μSvh^{-1} at a distance of 3 metres from the source. At what **distances** from the source would the dose equivalent rate be (a) **16 μSvh^{-1}** and (b) **1 μSvh^{-1}?**

11. If the half-value thickness of a metal for gamma radiation is 36 mm, what **thickness** would be required to reduce exposure at a given distance from a source of gamma radiation to **3%** of its level **without** any screening?

12. In a nuclear reactor, fissions of uranium nuclei produce, on average, 3.2 x 10^{-11} J of energy each. Assuming **all** the energy turns into heat, **how many** fissions per second would be needed to produce heat at the rate of 1200 watts?

Exercise 49

1. Assuming that the effect of air resistance can be ignored, calculate the **speed** at which a 3 kg rock would reach the foot of a cliff if it fell from the top where its **potential energy** measured 4370 J.

2. The equation of a **straight line** graph is '**y = mx + c**'.
If a graph was drawn of the voltage '**V**' across the terminals of a **cell** against the current '**i**' drawn from the cell, show that it would be a straight line of gradient '**-r**' and that the line would intercept the voltage axis at **V = E**.
('**E**' and '**r**' are the cell's e.m.f. and internal resistance).

   Sketch the graph which would result.

3. A car tyre pressure is 28.1 lb/in^2 at a temperature of 10^{o}C. What would the pressure become if the tyre's **air temperature** increased **by** 15 C^o?

4. A woman of mass 60 kg is in a lift which is moving **down** between floors.
At one instant, the lift is **accelerating down** at 1.5 ms^{-2}.
What is her ***apparent*** weight at that instant and her ***actual*** weight?

5. How much **power** must be used by the body in pushing a shopping trolley which weighs 980 N at a steady speed of 0.8 ms^{-1} if, on letting go, it comes to a halt in 4 seconds with a uniform deceleration?

6. In a **balanced** Wheatstone bridge, three of the resistors measure **1 kΩ**, **2 kΩ** and **500 Ω**. What **three** possible values could the fourth resistor have?

7. How much **heat** is produced in 30 s in a 10 Ω resistor if a p.d. of 12 V is across it?

8. Calculate the **average power** dissipated by a resistor with an r.m.s. current of 500 mA flowing through it due to a **peak** alternating voltage of 17 volts.

9. A current of 2 amps flows through a 10 Ω resistor which is in **parallel** with a second resistor of **double** the resistance. What is the **voltage** across the second resistor and the **current** through it?

10. In a spectrometer with a grating of 4500 lines per cm, an emission line is viewed at an angle of 15.4^o in the **first order** spectrum. At what **angle** would the **same** line be viewed in the **second order** spectrum?

11. An electron makes a transition from a high energy level of -2.42 x 10^{-19} J in an atom to a lower level and a photon of wavelength 656 nm is emitted. Calculate the **energy** of the electron in the lower level.

12. What is the **quality factor** of 'fast neutrons' if an 80 kg man, absorbing 160 µJ of energy has a **dose equivalent** of 20 µSv?

Exercise 50

1. A radionuclide's activity falls to **6.25 %** of its initial value in a time of 24 hours. What is the value of its **half-life**?

2. Light of frequency 5×10^{14} Hz travels from air into glass with a refractive index of 1.60. What are the **speed**, **wavelength** and **frequency** of the light in the **glass**?

3. If the continuous spectrum of a white light source is viewed through a spectrometer, which **end** of the spectrum will be nearest to the central white line? Why?

4. Microwave radiation falls on two narrow slits in a metal barrier and forms an interference pattern. The **second** minimum from the centre of the pattern is detected by a probe when it is 6.3 cm and 14.1 cm respectively from the centre of each slit. What is the microwave **wavelength**?

5. Three resistors, **11 Ω**, **30 Ω** and **40 Ω** are connected in series with a 9.0 V **30 Ω** resistor?

6. A capacitor, in series with a resistor, is being charged from a battery. The **charging current** is to be monitored by a computer, interfaced with the circuit. The computer is programmed to draw a graph of current against time. Across which of the circuit's **components** should the computer be connected? Why?

7. The energy carried by a **photon** of radiation is given by '**E = hf**', where '**h**' is a constant. Sketch **graphs** to show how the energy varies with (a) **frequency** and (b) **wavelength**.

8. A 5000 μF capacitor in **series** with a 3.3 kΩ resistor is being charged from a 9.0 V battery. At the instant that the voltage across the **resistor** is 6.4 V, calculate the **charge** on the capacitor plates and the charging **current**.

9. A car, travelling along a straight road at 50 ms^{-1}, decelerates uniformly to rest in a time of 10 seconds. How **far** does it move in coming to rest?

10. A 1600 kg car, travelling at 20 ms^{-1}, crashes into the back of a **stationary** vehicle of mass 2400 kg. Calculate the combined **speed** of the wreckage immediately after the collision and the loss of **kinetic energy** due to the impact, assuming that the cars lock together on impact.

11. What **impulse** is imparted to a 100 g bullet fired from a gun at 350 ms^{-1} and what is its **kinetic energy**?

12. The volume of a fixed mass of gas is measured at a number of different pressures. Its temperature remains constant throughout. Using the pressure and volume data, what **graph** would be drawn to yield a **straight line through the origin**?

ANSWERS TO EXERCISES

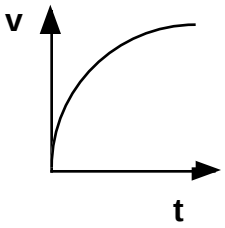
Exercise 1

1. 5 ms^{-2} 2. $^1/_2\ at^2$ 3. metres per second
4. 9 J 5. (a) 20 N (b) 19.3 N (c) 10 N 6. 105 m
7. displacement, weight, velocity, momentum, force; rest are **scalars**
8. 5 N left; 2 ms^{-2} 9. 42 J 10. 17 ms^{-1} 11. (a) yes (b) no
12. Sock on the rim of washing machine drum while spinning.

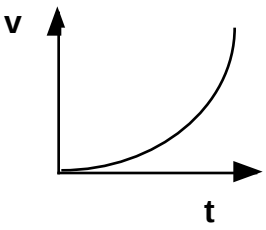
Exercise 2

1. 80 s 2. 22.5 ms^{-1} 3. (a) 12 N (b) 12 N
4. 4 s; 50 m/s 37^o to vertical 5. (a) 75 kg (b) 75 kg
6. average velocity 7. 12 ms^{-1} and 24 m 8. 19.2 ms^{-1}
9. 5.3 ms^{-1} 10. 2650 J 11. 2.5 m 12. 136 W

Exercise 3

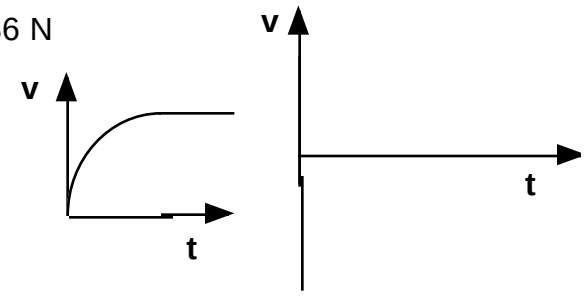
1. Displacement, metres 2. 2.5 N 3. 24 N
4. 8.5 ms^{-1} at 021^o 5. 1.5 kW 6. 0.5 ms^{-2}; 2 N right; 4 N to left
7. 90 m 8. Directly proportional to acceleration
9. 

10. 3 kg 11. 4500 N; 2.5 ms^{-2} 12. 16 ms^{-1}

Exercise 4 1. 20 N 2. 4.7 N at 24^o to 2 N force 3. 6.5 Nkg^{-1}
4. 60000 $kgms^{-1}$ 5. -12 $kgms^{-1}$ 6. 1275 J
7. initial velocity; change of velocity due to acceleration
8. Force exerted on the rocket by exhaust gases 9. 800 N; 800 N
10. 6.25 x 10^6 N 11. 1 in 17 or ~6 % 12. 

Exercise 5

1. (a) distance (b) displacement 2. 40^o 3. 5 s
4. ms^{-1} 5. 180 m 6. 2400 J 7.
8. 9.8 ms^{-2} down 9. 861 N; 686 N
10. 2900 kN 11. 400 N 12.

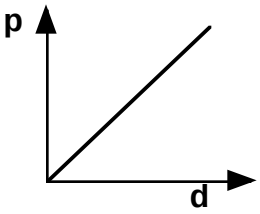


Exercise 6

1. 12 $kgms^{-1}$ 2. no energy lost 3. force of apple on Earth
4. 0 J 5. 8 Ns 6. change of momentum 7. weight;momentum
8. 20 ms^{-1} 9. 14 ms^{-1} 10. V_v = 104 ms^{-1} ; V_h = 60 ms^{-1}
11. 2 ms^{-2}; 6N right; 4N 12. 12.5 N; 0.1 N

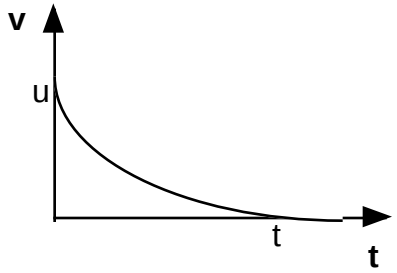
Exercise 7

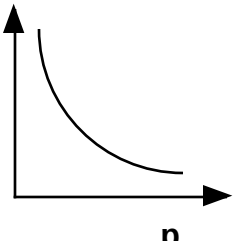
1. 4 s; starting point 2. 4 ms^{-2} 3. 30 ms^{-1} 4. 630 N
5. 25 N 6. 1.7 ms^{-2} down 7. 41^o
8. Force of cart on horse 9. 10800 N 10. 340 N; 85 kg
11. 12. 24 cms^{-1} ; 0.096 J



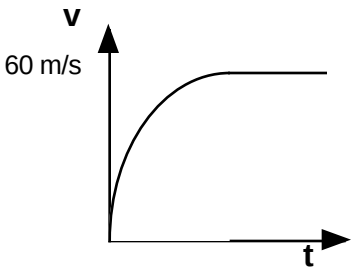
Exercise 8

1. 1.96 x 10^8 N upwards 2. (a) 13.6 (b) 13600; mercury 3. 4410 Pa
4.
5. 6 s 6. 0 N
7. 19.6 N; 34 N 8. 300 N
9. 500 ms^{-1} 10. 273 K; 253 K; 373 K; 0 K
11. 1.45 x 10^5 Pa 12.





Exercise 9

1. 1000 g
2. 0.096 J
3. 

4. 750 N
5. 3250 N
6. 117 cm^3
7. 1440 m
8. 2.4 ms^{-2}
9. 32^o
10. (a) 153 ms^{-1} (b) 119 ms^{-1}
11. 100 N down
12. 730 cm^3

Exercise 10

1. 52 ms^{-1}
2. 4 ms^{-2}
3. 4.1 N; 0.7 N
4. 2.21 cm^3
5. 30 tonnes
6. (a) 78 kg (b) 763 N
7. 392^oC
8. 6.5 s
9. 30.9 kW
10. 27.5 ms^{-1}
11. velocity
12. 8.6 ms^{-1}

Exercise 11

1. volt
2. 25 V
3. 36 C
4. (a) 20 Ω (b) 5 Ω
5. 10 A
6. 192 W
7. 24 J
8. 800 N
9. 293 K
10. 800
11. 2.5 s
12. 4 m further

Exercise 12

1. 2.5 V
2. 1 mA
3. 3 V
4. 60 Ω
5. Smaller than either
6. 960 W
7. ohm
8. 0.24 mJ
9. 30 : 1
10. 45 N; 5 N
11. 60 N
12. 20 cms^{-1}; 0.35 J

Exercise 13

1. 1.5 Ω
2. 225 J
3. 500 µA
4. 20 Ω
5. 20 kA
6. 1 GJ
7. Parallel; so that heater cannot be on without the motor
8. 10 volts
9. Force of ball on foot
10. Straight line through origin
11. (240 +/- 40) N
12. 1200 kgm^{-3}

Exercise 14

1. Parallel 2. 960 Ω 3. 20 Ω 4. 11.5 V
5. 0.1 A 6. 100 W 7. 1.2 V 8. 0 Ω
9. (a) very large (b) zero 10. 1.5 m 11. 26 kPa 12. 8.9 ms^{-1}

Exercise 15

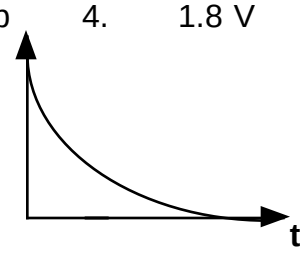
1. watt 2. 3.4 volts 3. 10 Ω 4. power
5. 15 J 6. (a) 4.5 V (b) 4.0 V 7. charge
8. same 9. 10.4 s; 38.5 ms^{-1} 10. 390 J
11. 4.04 x 10^5 Pa 12. (2.34 +/- 0.01) V

Exercise 16

1. (a) 3.0 V; 2.4 Ω (b) 1.5 V; 0.6 Ω 2. Yes, if **two** resistors are in parallel
3. ampere 4. 960 Ω 5. 500 W 6. 100 Ω
7. 6910 C 8. 2 Ω; 10.0 V 9. 9.8 ms^{-2} down
10. 10 s; 3460 m 11. 4.8 Ns in final direction 12. 47 C^o rise

Exercise 17

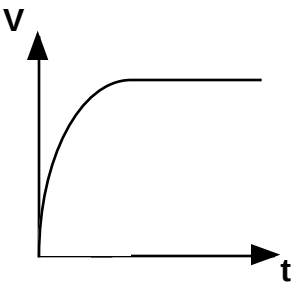
1. 2 Ω 2. 10.2 V 3. coulomb 4. 1.8 V
5. 325 V 6. 2200 µF 7. 72 mJ 8.



9. 9 mA 10. d.c. 11. 16^{o}C
12. a = 2.0; bigger relative error; (4400 +/- 900) N

Exercise 18

1. energy stored 2. 18 mJ 3. 9 mJ 4.



5. 0.36 J 6. 12 V
7. (a) 300 mA (b) 300 mA 8. 330 Ω 9. 8 V
10. First is a temperature, second a temperature **change**.
11. 900m 12. (2.54 +/- 0.02) kg

Exercise 19

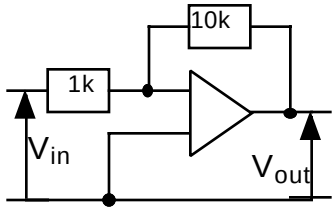
1. 60 mC 2. 0.36 J 3. 10000 µF

4. (a) 600 mA (b) 1.2 A 5. ~1.5 kW

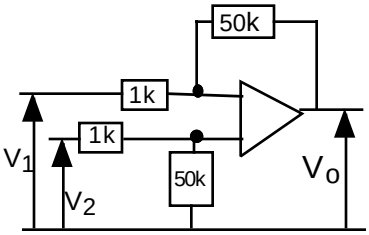
6. (a) - 5.0 V (b) 2.0 V (c) 0 V (d) 12 V (e) ~ -14 V (saturation)

7. $V_o = {}^{R_f}/_{R1}(V_2 - V_1)$; amplifies 'difference between input voltages'

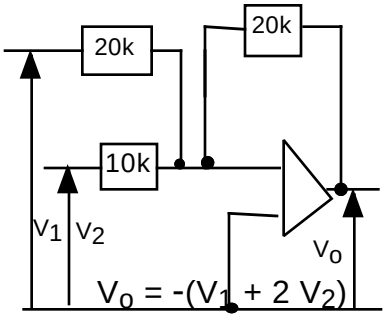
8. (a)



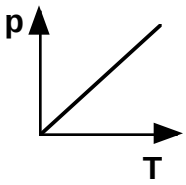
(b)



9.



10.



11. (a) impulse (b) change of velocity

12. 1.9×10^5 Pa to 2.3×10^5 Pa.

Exercise 20

1. 12 volts 2. power supply voltage 3. $V_o = -{}^{R_f}/_{R1}V_1$

4. Op-amp cannot supply large enough current; transistor

5. Stays at zero 6. (a) zero (b) very large 7. 20 mC

8. 200 9. 67 % 10. 3.6×10^5 Jkg^{-1}

11. 2000 $Jkg^{-1}K^{-1}$ 12. heat loss to the surroundings

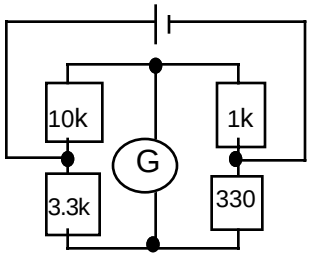
Exercise 21

1. 1.33 Hz 2. 0.25 s 3. 1.37 4. frequency

5. (a) totally internally reflected (b) refracted into air, partially reflected

6. 0.52º 7. (a) 400 (b) 25 (c) 48. 2×10^8 ms^{-1}

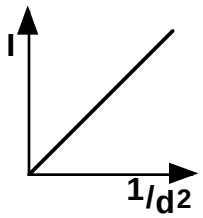
9.



10. 1500 Ω; 667 Ω 11. farad

12. systematic error

Exercise 22

1. 48.8^{o} 2. 4.4×10^{14} Hz 3. (a) 4.53×10^{-7} m (b) 4.4×10^{14} Hz
4. 3 ms^{-2} right; 18 N right
5. 2cm, 6 cm, 10 cm etc 6. sound would be quieter than normal
7. 2.12 m 8. 

9. 375 W 10. 6 m 32 s
11. $-10^{o}C$ 12. increases

Exercise 23

1. 391 nm 2. 49.5^{o} 3. circular, centre the gap
4. 0.2 s 5. 42^{o} 6. 1.44 7. 3×10^{-11} m
8. 200 kHz 9. watt
10. (a) 0.81 J (b) 0.405 J; difference due to heating of circuit resistance
11. 25.5 N vertically downward 12. (a) 1000 x (b) 10 x

Exercise 24

1. 225 m 2. 124 N 3. 5.05×10^{5} Pa 4. 1.37×10^{5} Pa
5. 18.13 g; 0.07 g 6. 226 V 7. 20 Ω 8. 16.7 ms
9. 522 nm 10. 38.5^{o} 11. 24.6^{o} 12. speed, wavelength

Exercise 25

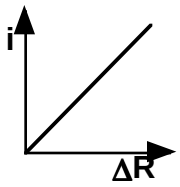
1. 34.5^{o} 2. 3.7×10^{-19}J 3. 4.1 mA 4. 30 : 1
5. 0.1 V; 4.2% 6. 16 N 7. 1.4×10^{5} Pa
8. 25 ms^{-1}; 2 ms^{-2}; 125 m 9. 900 J 10. 1300 kg
11. 440 $Jkg^{-1}K^{-1}$ 12. 34 N

Exercise 26

1. 4 mJ 2. 1.33 3. 1.61 4. 1 kHz
5. 2.83 m 6. 4 cms^{-1}, right 7. 89 mJ 8. 720 W
9. Systematic error 10. $50^{o}C$ 11. 13.4 kJ 12. 63%

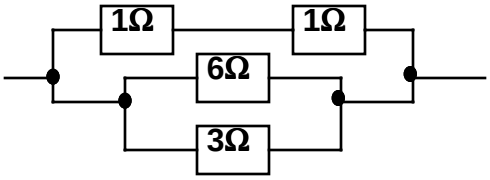
Exercise 27

1. 3.2×10^{15} 2. 1.95×10^{8} ms^{-1} 3. 9.3 cm^3
4. 550 N 5. 0.3 kgms^{-1} in direction after bounce
6. Force of Moon on Earth 7. 5 s; no 8. 7^o 9. 18 J
10. 3 V, 3 V 11. 5.3 V; 2.4 mA; 37 mC 12.



Exercise 28

1. 2.95 m 2. 1.58 3. +14 D, +20 D, -10 D 4. 301 nm; U.V.
5. 2.91×10^{-19} J 6. 7. 1.0 V; 8.0 V
8. 81 mJ; 9 V
9. 8.3 Ω; 750 mW
10. 1.8 mA; 22.5 mC
11. joule
12. 60s; 60 s



Exercise 29

1. 36.2 km;7.6 km 2. 0.23 Nkg^{-1} 3. 588 N; 1.7 ms^{-2} up
4. ρ = 1240 kgm^{-3} (> water) so sinks 5. 5.3 g 6. 27 %
7. 60 Ω and 30 Ω 8. force-time; change of momentum
9. 3×10^{-4} m^3; 0.03 m^2 10. (a) 40000 (b) 4.2×10^{-3} (c) 10^{-6} (d) 10^{-5}
11. 0 J; force not moved in its own direction (up)
12. '59^o' ray partially refracted into water at 77^o; other ray totally internally reflected in glass.

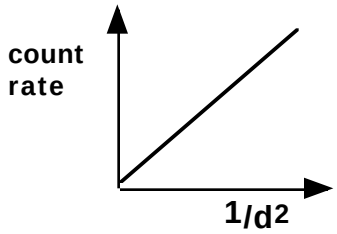
Exercise 30

1. 4 cm 2. 16.1 m; 1.77 s 3. 4.5 Ns, away from racquet
4. 225 kJ 5. 2 A; 12 V 6. -10 V 7. 5000μF
8. 1.4 N 9. 14.3 N at 21^o to 6 N force 10. 66.2^o
11. 4.2×10^{18} 12. 13^{o}C

Exercise 31

1. 3.9×10^{-19} J; yes
2. 160 kBq
3. 6 mins.
4. alpha, gamma; thick lead
5. 16.7 ms; period
6. 10 V
7. 167 N; 17 litres
8. 1.25 kgm^{-3}; 0.08 kgm^{-3}
9. 1.03×10^{-7} m
10. 1.12×10^{7} Pa
11. displacement without acceleration; extra displacement due to acceleration
12. 75 m

Exercise 32

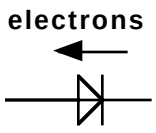
1. 200 µGy; 13.3 μGyh^{-1}
2. 8000 N
3. 25 ms^{-1}; 125 m
4. 3.24×10^{-11} J; 1.54×10^{18}
5. one sixteenth
6. 167 million
7. 470 W
8. 1.56
9. 

Straight line would not go through origin.
10. 2.5 litres
11. 0.2 Ω
12. 10000 µF

Exercise 33

1. 73.8 kg
2. 38.5 $\mu Sv/_{wk}$
3. 20 μSvh^{-1}
4. (a) acceleration (b) velocity
5. 7×10^{-30} kg
6. 2.26×10^{8} ms^{-1}
7. 0.24 s
8. 72.5 m
9. 2900 N; 780 N
10. 1.67 ms^{-2}
11. 10 Hz
12. 8.2% drop

Exercise 34

1. 3 mm; 10^{-11}s
2. 50 mGy
3. Q = 3
4. 1350 N
5. Stop; 756 kJ
6. 321 nm
7. 0.2 m^2; 2×10^{-3} m^{-3}
8. 

9. Stays the same; sinks lower
10. 2 Ω
11. 192 Ω
12. 4320 C

Exercise 35

1. 500 g; 20 g (to one sig. fig.) 2. 9.5 ms^{-2} 3. 0.75 Ω; 105 mA
4. 11 mm 5. 320 W 6. 4330 N 7. watt
8. 19.6 MJ 9. 12 V 10. 4 times 11. 260 N
12. $1/32$

Exercise 36

1. - 2. 592 nm 3. 9.6 x 10^{-15}J 4. 7.5 x 10^{6} ms^{-1}
5. electrical to heat 6. 8.4 mC; 3.0 mA 7. 14.8 Ω
8. (a) 10 % (b) 0.2 % 9. 5.7 kN 10. 197 ºC
11. 1600; 1600; 255 cm^3 12. (a) current (b) capacitance

Exercise 37

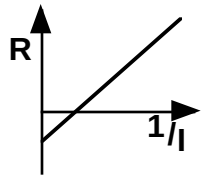
1. 2 s 2. straight line and through origin 3. 580 N
4. ~54 mins; heat lost to surroundings 5. 0.49 litres
6. 9.1 A 7. 25750 N 8. 12.1 ms^{-1}
9. 20 s 10. 3 x 10^{7} ms^{-1} 11. 19.2 days (460 h)
12. 120 µSvh^{-1}

Exercise 38

1. ~ 28 mins 2. 12 Ω and 4Ω 3. 3.7 x 10^{-28} kg
4. (a) 40.5 Wm^{-2}; 6.5 Wm^{-2}; 1.5 m 5. 6.5 x 10^{15} photons
6. (a) 92 p, 143 n (b) 6 p, 6 n (c) 82 p, 132 n 7. 660 Ω+/- 30 Ω
8. 2.5 C 9. 22.5 J; 4.74 ms^{-1} 10. 35º; 37 N
11. 1600 N 12. ~30 s

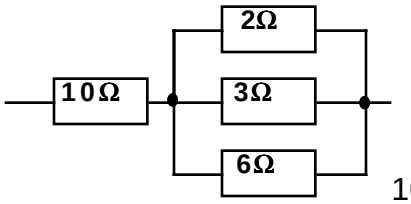
Exercise 39

1. 70º 2. 126 MN 3. 74 % 4. (a) e.m.f. (b) 'r'
5. 42.7 cm from '100 Ω' end 6. 20; - 8 V; ~14 V
7. 133 Ω 8. 0 to 8 volts
9. 90 mC; 18 s; 1800 Ω 10. 2.5 x 10^{7}; 5



11. (a) force-time (b) velocity-time (c) acceleration-time 12. 265 cm

Exercise 40

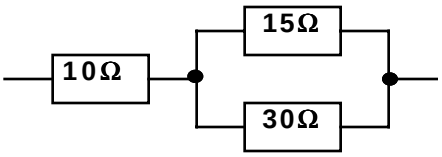
1. 1.5×10^{-17} J; 2.25×10^{16} Hz
2. 275 s
3. 18.8^{o}
4. 49.7^{o}
5. 90, 234; 91, 234; thorium, protactinium.
6. 0.29 W
7. 

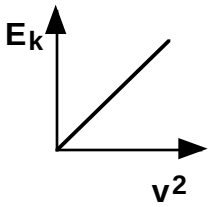
8. 150 kΩ
9. 320 mA
10. 55 kg; 770 N
11. 86 m +/- 6 m
12. 1.5 ms^{-1}

Exercise 41

1. 80 kΩ; 160 mV
2. 12 µA; 720 µJ
3. 545 nm
4. ~3 %
5. 8.1 Ns; time of contact
6. 1620 J; 540 W
7. 20; 50
8. 14.7 kPa
9. +/-3 Ω
10. 6.0 N up slope
11. 28 kN
12. 1 Ω; 500 mA

Exercise 42

1. 1.25×10^{19}
2. 28 GWm^{-2}
3. 185 kBq
4. 30 mJ
5. 2.6 µSv
6. 2400; 150; 24 μSvh^{-1}
7. 5000 µF; 0.2 J
8. 

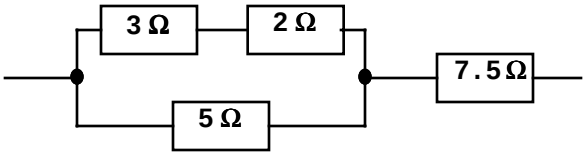
9. 8.2 V
10. 

11. 157 K
12. 135 ^{o}C

Exercise 43

1. 1.9×10^8 ms^{-1}; 286 nm
2. 1.48
3. 70.2º
4. 123 m
5. 4 kN; 800 kJ
6. 1.9 V
7. 5 h
8. 94.5 kJ
9. 236 kBq
10. 20 cm
11. 15 min
12. Q = 3

Exercise 44

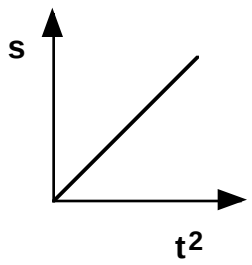
1. 3.35×10^{-11} J
2. 103 nm
3. 2.93×10^{-19} J
4. 230 m
5. 150 W
6. 1.13 m
7. 59.5º
8. 207 cm^3
9. 0.5 ms^{-2} acceleration upwards
10. 

11. 1.60; 56.2º
12. 22.2 days

Exercise 45

1. 5.4×10^9
2. (a) 0.40 µSvh^{-1} (b) 0.025 µSvh^{-1}
3. 33 mm
4. 3.1×10^{-29} kg
5. 480 nm; 13.9º
6. Minimum reading. Path difference is odd number of half wavelengths.
7. 9.35×10^{14}
8. 4.9×10^{-7} m; 3.8×10^{14}Hz
9. 8525 Ω
10. time
11. 9.0 N
12. (a) 44 yds (b) 0

Exercise 46

1. e.g. 11.7 cm, 14.5 cm, 17.3 cm
2. 3.1×10^{31} J
3. 7.5 c.p.m.
4. 2.47×10^{20} Hz
5. ~6000
6. 122.7 g+/- 0.3 g
7. 8.3 V; 150 mA
8. 0.48 J
9. 1.93 N; 14.5 cm^3
10. volt
11. 

12. 4 ms^{-2}

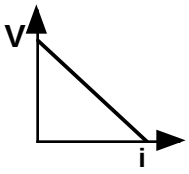
Exercise 47

1. 1500 µSv 2. 10 to 11 mm 3. ~500 nm
4. 4.84×10^{14} Hz 5. 50.6^{o} 6. 0.11^{o} 7. 2 Ω; 2 W
8. 1.2 kΩ 9. 10000 µF
10. (a) 50 Hz (b) 100 Hz (c) 2 kHz 11. 30 kN 12. 245 N

Exercise 48

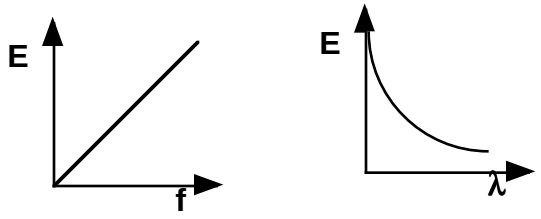
1. 5 N down slope 2. 2.4 ms^{-1} in direction of heavier car.
3. Force of water on compressed air 4. Stays same; less deep
5. 3.44×10^{-17} J; 8.7×10^{6} ms^{-1} 6. 2 Ω 7. 8 µF
8. -0.48 V 9. weight of fluid displaced; both
10. (a) 1.5 m (b) 6 m 11. ~180 mm 12. 3.75×10^{13}

Exercise 49

1. 54 ms^{-1} 2. 

3. 29.6 lb/in^2
4. 498 N; 588 N 5. 16 W 6. 1 kΩ, 250 Ω, 4 kΩ
7. 432 J 8. 6 W 9. 20 V; 1 A
10. 32.1^{o} 11. -5.45×10^{-19} J 12. Q = 10

Exercise 50

1. 6 hours 2. 1.88×10^{8} ms^{-1}; 375 nm; 5×10^{14} Hz
3. violet; shortest wavelength diffracted least 4. 5.2 cm
5. 3.33 V 6. resistor; current α voltage across R, not C
7. 

8. 13 mC; 1.94 mA

9. 250 m 10. 8 ms^{-1}; 192 kJ

11. 35 Ns; 6130 J 12. volume against inverse of pressure (or vice versa).