Answers

1.1

1 **a** displacement

b instantaneous velocity

c instantaneous acceleration

d instantaneous speed

e average velocity

f average speed

g position vector

h distance

2 **a** Motion in physics depends on the point of reference that we choose to measure the position vector of a moving body.

b Kinematics is a branch of physics, developed in classical mechanics, that describes the motion of points, bodies and also system of objects without considering the forces that cause the object or system of objects to move.

3 **a** the gradient of a velocity against time graph.

b the gradient of a position against time graph.

c the area under a velocity against time graph.

d the area under an acceleration against time graph.

1.2

Everyday definition	Key term	Scientific definition
Speeding up or slowing down	acceleration	the rate of change of velocity
How fast an object moves in a certain direction	velocity	the rate of change of displacement
A study about motion	kinematics	a branch of physics, developed in classical mechanics, that describes the motion of points, bodies and also systems of objects without considering the forces that cause the object or system of objects to move

Everyday definition	Key term	Scientific definition
The location of a body	position vector	a straight-line vector that connects the point of reference to the location of a body at a certain time
The total movement of a body without considering the direction	distance	a scalar quantity that defines the total length of the trajectory covered by a moving body without consideration the direction of motion
How far a body is displaced in motion	displacement	the change in position vector

1.3

Units (SI or non SI base units)	Correct quantities
km, cm, m	position, displacement, distance
m s^{-1}, km h^{-1}	velocity, average velocity, speed, average speed
m s^{-2}	acceleration
s, h	time

Quantity	Scalar or vector?
average speed	scalar
average velocity	vector
acceleration	vector
velocity	vector
distance	scalar
displacement	vector
speed	scalar
position	vector
average acceleration	vector
time	scalar

Students' own responses

2.1

1 The newton.

2 The gravitational force between the mass of a planet and a body.

3 The force that arises in a body when it is stretched or compressed.

4 The force that arises when two bodies are in contact directed normally to the surface creating the force.

5 The force acting on an object in a fluid due to a difference in pressure at the top and bottom of the body.

6 A force that arises as a result of the tendency of motion between two rough surfaces that come into contact each other.

7 The force acting against the motion of an object that is moving through a fluid (gas or liquid).

8 The magnitude and direction of all the forces acting on a chosen body.

9 Internal and external forces.

10 The tendency of a massive body to remain in its current state of motion.

2.2

1 net external force / resultant force

2 inertia

3 equal and opposite

4 **a** the same

b opposite

c different

d the same

5 zero

2.3

the road; normal force; normal force and frictional force; the same;

3.1

1 product; displacement

2 joule

3 work done

4 zero

5 zero

6 position; work done

7 power

8 energy, motion

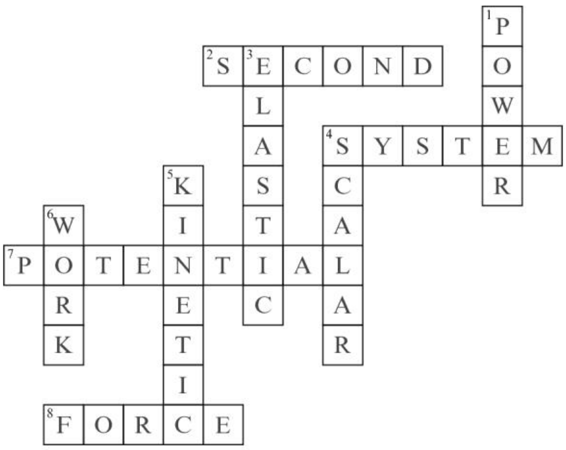
9 energy, conserved

10 isolated

11 system, outside

12 energy

3.2



4.1

1 force

2 external force

3 mass

4 force

5 kinetic energy

6 kinetic energy

7 momentum

8 force

9 velocity

10 direction, magnitude (*or vice versa*)

4.2

1 kg, g, tonnes — mass

m s^{-1}, km h^{-1} — velocity, speed

kgm s^{-1} — momentum, impulse

s, h — time

kgm s^{-2}, N — force

2

Quantity	Scalar or vector?
mass	scalar
change of velocity	vector
time	scalar
momentum	vector
velocity	vector
force	vector
impulse	vector
speed	scalar

4.3

1 net, momentum

2 vector, velocity

3 momentum, gradient

4 approach, separation (*or vice versa*)

5 momentum, impulse

5.1

1 **a** position

b impulse

c acceleration

d velocity

e speed

f displacement

g momentum

2 translational equilibrium — The centre of mass of the body remains at rest or moves in a straight line at constant speed

moment of inertia — A measure of the distribution of mass of an extended body about an axis of rotation

kinetic energy of rotational motion — $\frac{1}{2}I\omega^2$

conservation of angular momentum — When the net torque on a system is zero, the angular momentum is conserved

5.2

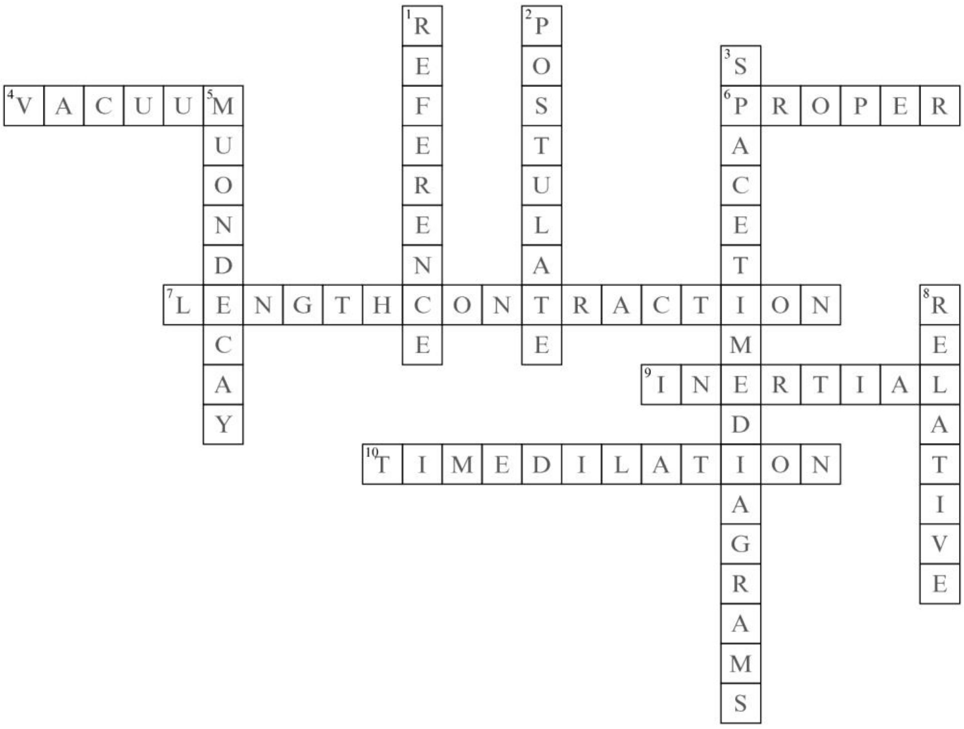
Quantity	Correct unit
moment of inertia	kg m^2
product of moment of inertia and angular velocity	kg m^2 s^{-1}
force	kg m s^{-2}
momentum	kg m s^{-1}
energy or work	kg m^2 s^{-2}

Quantity	**Correct unit**
change of angular position	rad
rate of change of angular position	rad s^{-1}
rate of change of angular velocity	rad s^{-2}

5.3

Scalar	**Vector**
kinetic energy of rotational motion	angular momentum
the work done by the net torque	angular velocity
mass	torque
	angular impulse

6.1



6.2

Inertial frames	**Noninertial frames**
A sky diver falling at terminal velocity.	A car accelerated along a straight road.
A man moving with constant velocity in a straight line.	A rocket moving upward with constant rate of change of velocity to outer space.
A woman swimming with constant velocity.	A bird flying at constant height, increasing speed.
A ball falling freely.	

7.1

1 **a** kinetic, intermolecular

b difference, hotter, cooler

c temperature

d zero

e temperature

f heat capacity

g latent heat, pressure

h fusion, vaporisation

i latent heat

j vaporisation, temperature

2

change of phase	**description**	**energy transfer**
melting	when a solid changes to a liquid	thermal energy is transferred to the solid
freezing	when a liquid changes into a solid	thermal energy is transferred away from the liquid
vaporisation (or boiling)	when a liquid changes into vapour	thermal energy is transferred to the liquid
condensation	when a vapour changes into a liquid	thermal energy is transferred away from the vapour

7.2

1 H**E**A**T** ENERGY

T**H**ER**M**A**L** ENERGY

I**N**T**ER**NA**L** ENERGY

T**EM**P**E**R**A**T**U**R**E**

S**P**E**C**IF**I**C H**EA**T CAPACITY

2

SI base unit	Quantity
kg m^2 s^{-2}	internal energy, thermal energy, kinetic energy, intermolecular potential energy
kg m^2 s^{-3}	power
kg m^2 s^{-3}	radiated intensity
kg m s^{-3}	spectral intensity
m^2 s^{-2} K^{-1}	specific heat capacity

7.3

1 **a** A method of energy transfer that applies mainly to fluids (gases and liquids).

b Temperature.

c The method of transferring thermal energy that does not need a medium.

d A black body.

e The surface area *A* and the absolute temperature of the surface *T*.

f Freezing.

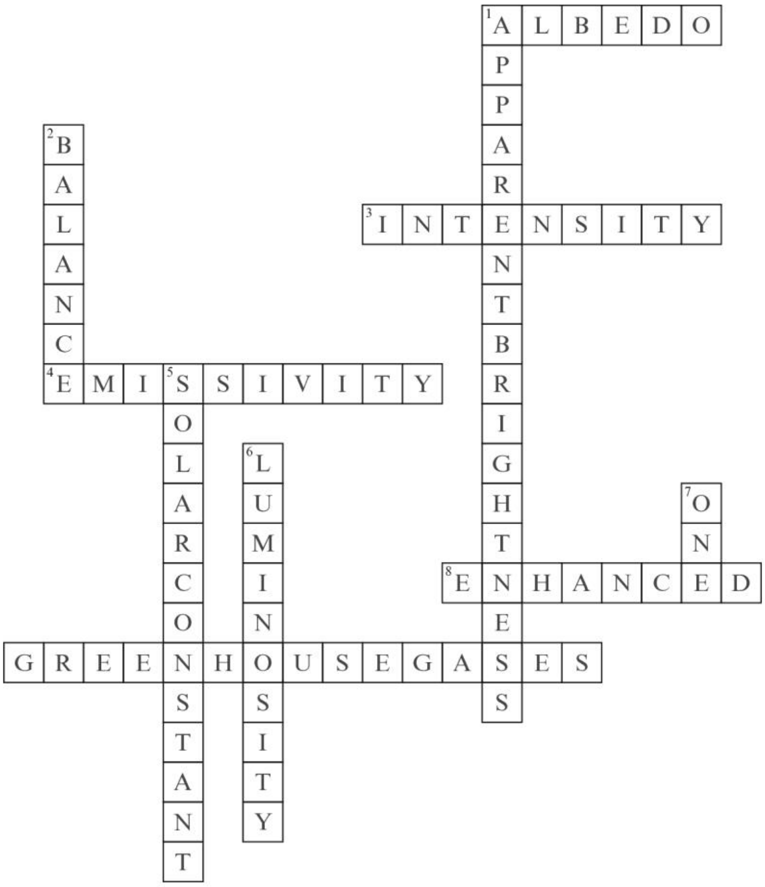
g The radiated intensity.

h Fluid.

2 solid, liquid and gas

3 Joule

8.1



8.2

INTENSITY

LUMINOSITY

APPARENT BRIGHTNESS

POWER

ALBEDO

WAVELENGTH

TEMPERATURE

SOLAR CONSTANT

EMISSIVITY

ENERGY

8.3

1 Human-made

2

Greenhouse gas	**Natural source**	**Anthropogenic origin**
N_2O	forests, oceans, soil and grasslands	burning fossil fuels, manufacture of cement, fertilisers, deforestation (reduction of nitrogen fixation in plants)
CH_4	wetlands, oceans, lakes and rivers, termites	flooded rice fields, farm animals, processing of coal, natural gas and oil, burning biomass
CO_2	forest fires, volcanic eruptions, evaporation of water from oceans	burning fossil fuels in power plants, cars, aeroplanes, burning forests
H_2O	evaporation of water from oceans, lakes and rivers	irrigation

9.1

1 **a** one mole

b normal

c one mole

d atmosphere

e temperature

f internal energy

2

Ideal gas laws	Constant quantity	Changing quantities
Boyle–Mariotte law	Temperature	Pressure and volume
Charles' law	Pressure	Volume and temperature
Gay–Lussac's law	Volume	Pressure and temperature

9.2

Scalar quantity; the unit is kelvin **temperature of gas**

The energy stored in an ideal gas; its value is directly proportional to the temperature of the ideal gas **internal energy of gas**

Pascals and atmospheres are both units for this quantity **pressure of gas**

According to Gay–Lussac's law, this quantity stays constant during the process experienced by an ideal gas **volume of gas**

A constant in ideal gas law; unit: J $mole^{-1}$ K^{-1} **gas constant**

A constant in ideal gas law; unit: J K^{-1} **Boltzmann constant**

Ideal gas molecules do not have this energy because there are no forces of attraction between the ideal gas molecules **intermolecular potential energy**

This constant represents the number of particles of one mole of a substance **the Avagadro constant**

9.3

1 **a** normal force

b volume, temperature

c pressure, volume, temperature

d pressure

e molecules, temperature

2 the Boltzmann constant; SI base unit: kg m^2 s^{-2} K^{-1}

the gas constant; SI base unit: kg m^2 s^{-2} mol^{-1} K^{-1}

the Avogadro constant; SI base unit: particles per one mole

10.1

a a closed

b an isolated

c volume

d energy

e work

f internal energy

g temperature

h thermodynamic

i thermal

j entropy

10.2

INTERNAL ENERGY

HEAT

WORK DONE

PRESSURE

VOLUME

TEMPERATURE

ENTROPY

EFFICIENCY

USEFUL WORK

INPUT ENERGY

10.3

1 Pascal: Pressure

Joule: Internal energy, Thermal energy, Work done by the gas

Kelvin: Temperature

Metre cubed: Volume

2

Process	**Constant quantity or quantities**	**Non-constant quantities**	**Quantity that has zero value**
Isothermal	temperature and internal energy	pressure, volume, work done by the gas, heat	none
Isobaric	pressure	volume, temperature, heat, work done by the gas, internal energy	none
Isovolumetric	volume	pressure, temperature, heat, internal energy	work done by the gas
Adiabatic	none	pressure, volume, temperature, work done by the gas, internal energy	heat

11.1

The work done per unit charge to move a point charge from one point to the other **potential difference between two points**

Materials with many free electrons per unit volume **conductors**

The potential difference across its ends divided by the current through it **electric resistance of a conductor**

The work done per unit charge in moving charge from one terminal of the battery to the other **electromotive force of a battery**

Materials with few free electrons per unit volume, through which thermal energy and electric current cannot readily pass **insulators**

The resistance of a conductor of unit length and unit cross-sectional area **resistivity**

The energy per unit time dissipated in a conductor **electric power**

The rate of flow of charge through the cross-sectional area of a conductor **electric current in a wire**

11.2

An ideal ammeter has zero resistance.

The current through a resistor is measured by an instrument called an ammeter.

The current that enters a junction must be equal to the current that leaves that junction.

An insulator has a very small number of free electrons.

Electric current in a wire is the rate of flow of charge through the cross-sectional area of a conductor.

11.3

a $\text{electrical resistance of a component} = \dfrac{\text{potential difference flowing across the component}}{\text{electric current flowing through the component}}$

b $\text{electrical resistance of a conductor} = \text{resistivity} \times \dfrac{\text{length of the conductor}}{\text{cross-sectional area of the conductor}}$

c $\text{electric power} = \text{current} \times \text{voltage}$

d $\text{electric power} = \text{current squared} \times \text{resistance}$

11.4

1 Joule (ampere)$^{-2}$ (second)$^{-1}$—internal resistance and resistance

Joule (ampere second)$^{-1}$—electromotive force and voltage

Ampere—current

Joule (second)$^{-1}$—electric power

Joule—work done

2 They are all scalar quantities.

12.1

Description	**Term**
a The condition when the driving frequency is equal or slightly less than the natural frequency of a system, resulting in maximum amplitude.	resonance
b The name for a repeating back and forth motion.	oscillations
c The time taken to complete one full oscillation.	period
d The maximum displacement away from the equilibrium position.	amplitude
e The number of oscillations per second.	frequency
f The type of oscillation in which the acceleration is proportional to and opposite to the displacement.	simple harmonic motion
g The quantity that represents the amount of kinetic and potential energy in simple harmonic motion.	total energy

12.2

1

Quantity	Unit
The total energy	kg m^2 s^{-2}
The amplitude	m
The frequency	s^{-1}
The period	s
The maximum acceleration	m s^{-2}
The maximum velocity	m s^{-1}

2 The period does not depend on amplitude.

The amplitude stays constant as time goes on.

12.3

Quantity	Scalar or vector?
frequency	scalar
period	scalar
acceleration	vector
velocity	vector
potential energy	scalar
displacement	vector
kinetic energy	scalar
total energy	scalar
phase difference	scalar
time	scalar
maximum speed	scalar
amplitude	scalar

13.1

1 energy, momentum

2 energy

3 period

4 frequency

5 wavelength

6 transverse

7 longitudinal

8 longitudinal

9 medium

10 electromagnetic

11 electromagnetic

12 sound

13 wavelength

14 matter

15 matter

13.2

FREQUENCY	s^{-1}
PERIOD	s
AMPLITUDE	m
WAVELENGTH	m
SPEED	$m\ s^{-1}$
DISPLACEMENT	m
DISTANCE	m
TIME	s

13.3

1 Sound waves and waves made on a rope/string and so on.

2 X-rays and radio waves and so on.

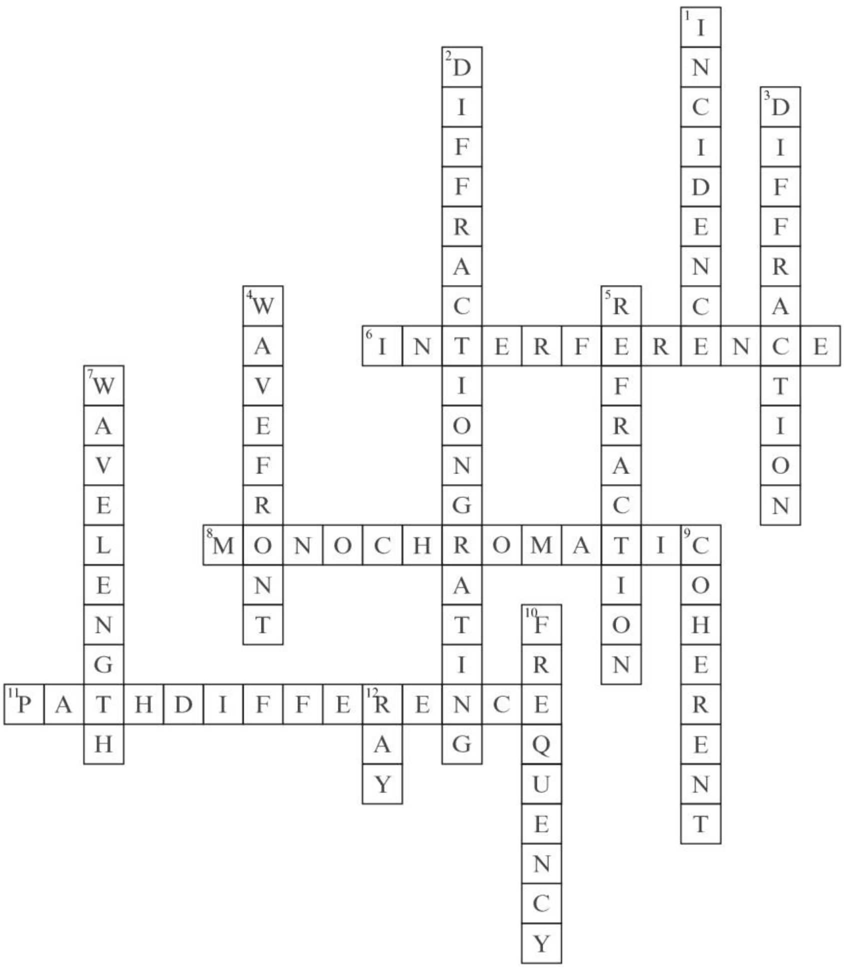
3 They are transverse waves, and they travel at the speed of light in vacuum.

4 Radio and television stations, X-ray machine, the Sun, computer screens, light bulb, mobile phones and so on.

5 Electromagnetic waves and gravitational waves and so on.

14.1

1



2

superposition of waves leading to zero (or minimum) amplitude	**destructive**
superposition of waves leading to maximum amplitude	**constructive**

14.2

1 When two or more waves of the same type arrive at a given point in space at the same time, the displacement of the medium at that point is the algebraic sum of the individual displacements.

2 The wavelength, frequency, energy and speed of the wave

3 (top row): refraction; refraction; refraction and dispersion; diffraction

(bottom row): refraction; reflection; reflection; diffraction

15.1

1 A wave formed by the superposition of two identical travelling waves in opposite directions.

2 A point on a standing wave where the displacement is always zero.

3 A point on a standing wave where the displacement is a maximum at some instant.

4 A standing wave with a frequency that is an integral multiple of the first harmonic frequency.

5 A wave that transfers energy from one place to another through oscillations in a medium.

6 The loss of energy of an oscillating system due to the presence of resistive forces.

7 The frequency of free oscillations of a body.

8 The frequency of the external force acting on the system.

9 Oscillations caused by an external periodic force acting on a system.

10 The condition when the driving frequency is equal or slightly less than the natural frequency of a system, resulting in maximum amplitude.

15.2

1 standing wave

2 stationary

3 energy

4 first harmonic

5 crests, nodes, antinodes

6 energy

7 antinodes

8 amplitude

9 amplitude

10 standing wave

16.1

1 Doppler effect, frequency

2 wavelength, approaching

3 wavelength, getting further away

4 frequency

5 wavelength

6 speed

7 intensity

8 red shift, away

9 frequency

10 wavelength

16.2

1 a i $\frac{\text{change in observed frequency}}{\text{emitted frequency}} = \frac{\text{speed of the source}}{\text{speed of light}}$

ii $\frac{\text{change in observed wavelength}}{\text{emitted wavelength}} = \frac{\text{speed of the source}}{\text{speed of light}}$

b i $\text{observed wavelength} = \frac{((\text{speed of sound}) - (\text{speed of the source}))}{\text{emitted frequency}}$

ii $\text{observed frequency} = \text{emitted frequency} \times \left(\frac{\text{speed of sound}}{(\text{speed of sound} - \text{speed of the source})}\right)$

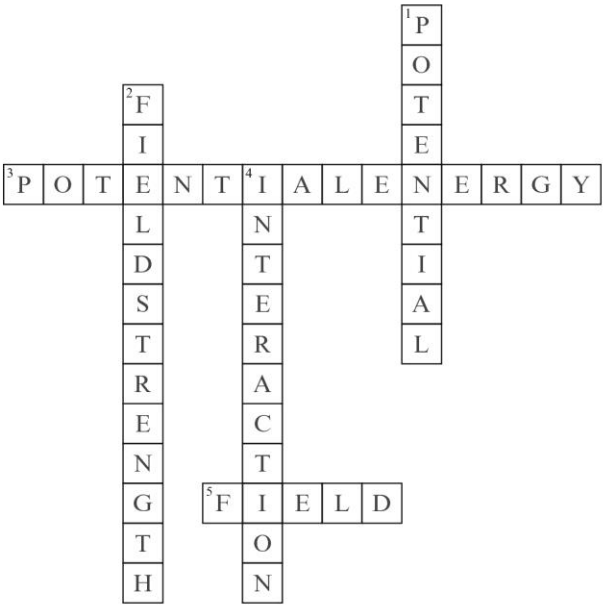
2 a

Quantity	SI base unit
speed of sound source	m s^{-1}
speed of light source	m s^{-1}
emitted frequency	s^{-1}
emitted wavelength	m
observed frequency	s^{-1}
observed wavelength	m
speed of light	m s^{-1}
speed of sound in air	m s^{-1}

b They are all scalar quantities.

17.1

1



2

Key term	Is it a quantity?	Scalar or vector?	SI base unit
gravitational interaction	yes	vector	kg m s^{-2}
gravitational potential energy	yes	scalar	kg m^2 s^{-2}
gravitational potential	yes	scalar	m^2 s^{-2}
gravitational field	no	n/a	n/a
gravitational field strength	yes	vector	m s^{-2}

17.2

1 **a** elliptical, ellipse

b equal, equal

c period

d momentum

e gravitation

2

Quantity	SI base unit
area	m^2
period	s
time	s

17.3

1 The two bodies are two point masses (idealised bodies with no physical size).

If the two bodies cannot be assumed as two point masses, then the distance between them must be very large compared to the physical size of the bodies.

2

Symbol	Name of quantity	SI base unit
F	the attractive force of gravitation	$kg\ m\ s^{-2}$
G	gravitational constant	$m^3\ kg^{-1}\ s^{-2}$
M_1	mass of the first body	kg
M_2	mass of the second body	kg

18.1

electric charge: A conserved property of matter.

electric field: A region of space where an electric charge experiences an electric force.

electric field lines: Tangents to these curves give the direction of electric field strength.

electric field strength: The electric force per unit charge on a small positive point charge.

electric potential: The work done per unit charge in bringing a small point positive charge from infinity to a position in an electric field.

electric potential energy: The work done to bring a set of charges from an infinite separation to their current position.

magnetic field: A region of space where a bar magnet would experience a magnetic force.

magnetic field lines: Tangents to these imaginary lines give the direction of a magnetic field.

magnetic flux: The product of magnetic field flux density, the area of coil and the cosine of the angle between the magnetic field direction and the normal to the coil.

magnetic flux density: The force per unit charge on a charge moving with unit velocity at right angles to a magnetic field.

18.2

1

Quantity	SI base unit	Vector or scalar?
magnetic flux density	kg $A^{-1}s^{-2}$	vector
electric potential	kg $m^2A^{-1}s^{-3}$	scalar
magnetic flux	kg $m^2A^{-1}s^{-2}$	scalar
electric potential energy	kg m^2s^{-2}	scalar
electric charge	A s	scalar
electric field strength	kg m $A^{-1}s^{-3}$	vector
magnetic force	kg m s^{-2}	vector
electric force	kg m s^{-2}	vector

2 Magnetic field lines, electric field lines, electric field, magnetic field

18.3

1

Symbol	Name of quantity	SI base unit
F	Electric force	kg m s^{-2}
k	Coulomb constant	kg m^3 A^{-2} s^{-4}
q_1	First electrical charge	A s
q_2	Second electrical charge	A s

2 **a** attract

b repel

c repel

19.1

a straight line, parabolic path

b straight line

c circular path

d spiral path

e straight line

f spiral path

g parabolic path

h parabolic path

19.2

accelerated

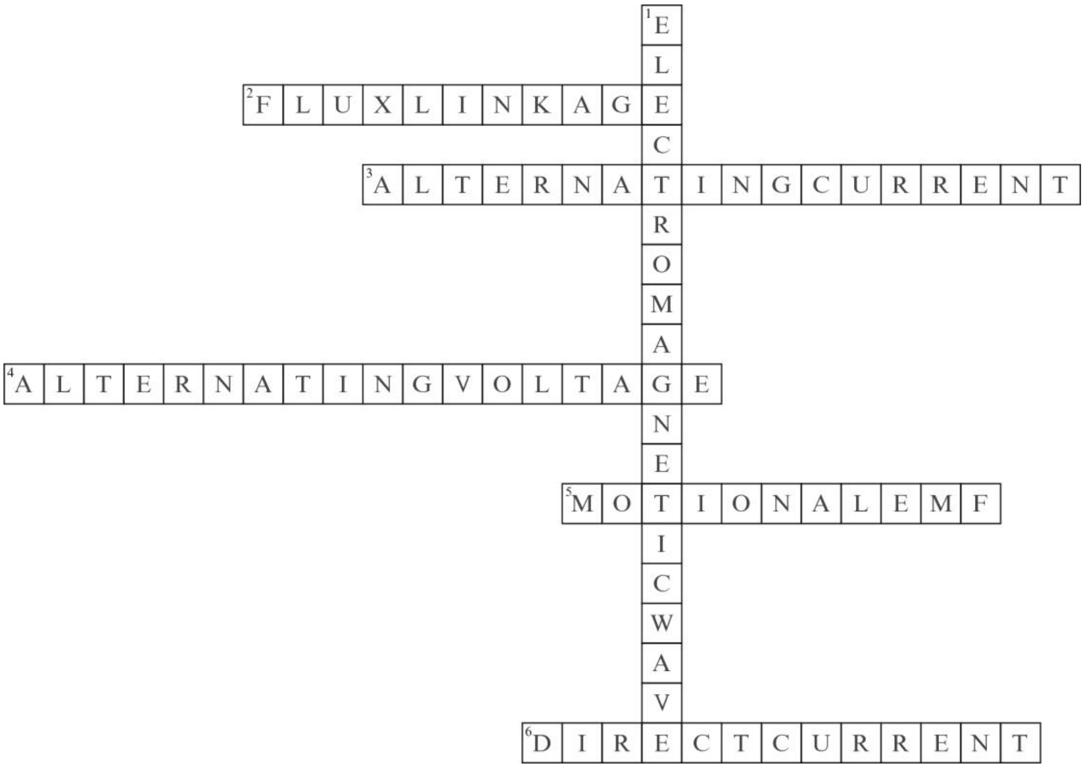
decelerated

decelerated

accelerated

20.1

1



2 **a** flow, oscillate

b direction, frequency, frequency

20.2

1 magnetic flux linkage

2 magnetic flux

3 weber

4 scalar, no direction

5 magnetic flux

6 magnetic flux, magnetic flux density

7 energy

8 magnetic

9 self-induction

10 electromotive force

20.3

1 decreases

2 decreases

3 decreases

4 decreases

21.1

Energy taking a set of specific values rather than a continuous set of values **discrete energy**

The set of wavelengths of light emitted by an atom **emission spectrum**

A representation of the discrete energies of an atom **energy level diagram**

The particle of light (a quantum of energy), a massless particle moving at the speed of light **photon**

The state of lowest energy **ground state**

Any state above the ground state **excited state**

The set of wavelengths that can be absorbed **absorption spectrum**

A quantity whose magnitude is an integral multiple of a basic unit **quantised**

The energy that must be given to an atom in its ground state so that the atom loses an electron **ionisation energy**

21.2

1 nucleus, electrons, nucleus

2 electrons, photons, photons

3 alpha

4 alpha, alpha, nuclei

5 electrons, electrons, nucleus

6 atom

22.1

What do we call the emission of electrons from a metallic surface when light is incident on the surface? **photoelectric effect**

What is the term for the metallic surface that releases electrons when light is incident on it? **photo-surface**

What will cause the current due to photoelectrons in the photoelectric effect to be zero? **stopping voltage**

What do we call the quantity of energy required to free an electron from a photo-surface? **work function**

What is the name for scattering of light off an electron? **Compton scattering**

What describes matter that has both particle and wave-like characteristics? **duality of matter**

What is the smallest quantity of something, for example, energy? **quantum**

What name is given to the electrons emitted in the photoelectric effect? **photoelectrons**

22.2

1 **a** ENERGY

b FREQUENCY

c FREQUENCY

d TIME

e INTENSITY

f WORK FUNCTION

g INTENSITY

h STOPPING VOLTAGE

2

Quantity	SI base unit
energy	kg m^2s^{-2}
frequency	s^{-1}
time	s
intensity	kg s^{-3}
work function	kg m^2s^{-2}
stopping voltage	kg $m^2s^{-3}A^{-1}$

3 They are all scalar quantities.

23.1

Nucleon: A proton or a neutron.

nucleon number: The total number of protons and neutrons in a nucleus.

nuclide: A nucleus with a specific atomic and nucleon number.

proton number: The number of protons in a nucleus.

electromagnetic interaction: The force given by Coulomb's law; acts on any particle that has electric charge; has infinite range.

weak nuclear interaction: The force that acts on protons, neutrons, electrons, and neutrinos to bring about beta decay; has very short range (10^{-18} m).

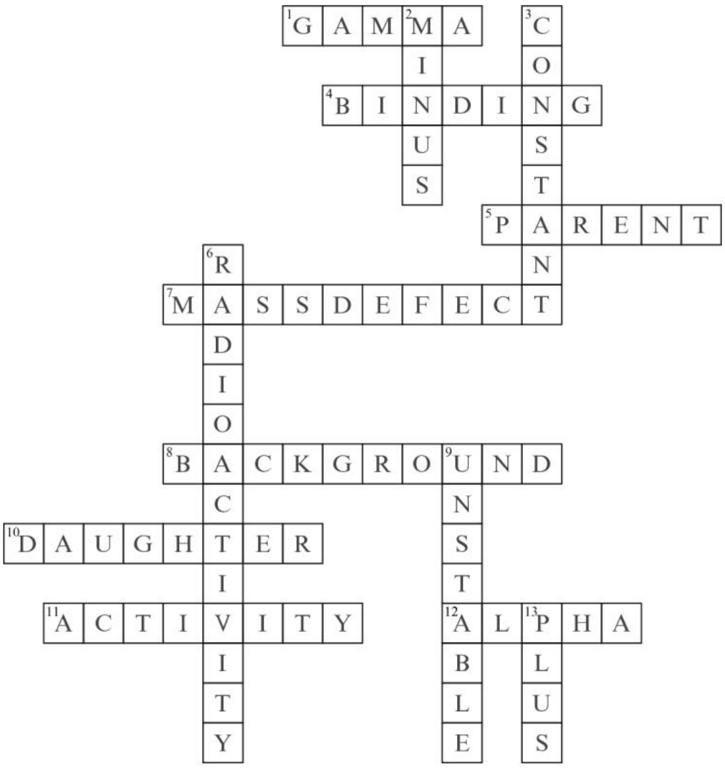
strong nuclear interaction: The force that acts on protons and neutrons to keep them bound to each other inside nuclei; has short range (10^{-15} m).

gravitational interaction: The force that acts on any particle with mass; has infinite range.

isotopes: Nuclei in different atoms of the same element containing different numbers of neutrons.

atomic mass unit: One twelfth of the mass of the neutral atom of carbon-12.

23.2



23.3

1 alpha

2 Alpha, beta, gamma

3 **a** Alpha particles

b Beta particles

c Gamma rays

4 **a** alpha particle
  b gamma ray
  c alpha particle
  d beta particle
  e gamma rays

23.4

1 energy, linear momentum, angular momentum

2 energy

3 hydrogen

4 energy

5 parent nucleus, daughter nucleus

24.1

induced fission: The splitting of a large nucleus into two smaller nuclei after it has absorbed a neutron.

spontaneous fission: The splitting of a large nucleus into two smaller nuclei without neutron absorption.

moderator: Used to slow the fast neutrons that are emitted in a fission reaction.

heat exchanger: The part of the reactor where the thermal energy generated in the moderator is extracted.

control rods: These are raised and lowered into the core of the reactor in order to control the rate of the reactions.

chain reaction: A reaction in which the products are used to keep the reaction going.

critical mass: The smallest mass of the nuclear fuel that can sustain a chain reaction.

24.2

1 heavy nucleus, lighter nuclei

2 lighter nuclei, heavier nuclei

3 nuclear reactor

4 graphite, water

5 cold water

6 concrete walls

7 greenhouse gases

25.1

nuclear fusion: The joining of lighter nuclei to form heavier nuclei, releasing energy.

nucleosynthesis: The formation of the elements.

main sequence: The stable phase in the life of a star; the star produces energy in its core, from nuclear fusion of hydrogen into helium.

red giants: Very large, cool stars with a reddish colour; the core is hot enough for the helium to fuse to form carbon.

white dwarfs: Small, hot stars no longer undergoing fusion; they get dimmer as they cool down.

instability region: A region on the Hertzsprung–Russell diagram with stars of variable luminosity.

parallax: The fact that when you look at an object from two different positions, the object appears to shift relative to the distant background.

proton–proton chain: The production of helium through the fusion of hydrogen.

planetary nebula: The expansion of a red giant, emitting mass and energy into space.

supernova: The explosion of a red super giant, emitting mass and energy into space.

Chandrasekhar limit: The maximum possible mass of a white dwarf, about 1.4 solar masses.

Oppenheimer–Volkoff limit: The maximum possible mass of a neutron star, about 3 solar masses.

25.2

Main characteristic	Type of star
Fuses hydrogen into helium.	main sequence star
Bright, large, cool, reddish, tenuous.	red giant
Even larger and brighter than red giants.	super red giant
Dim, small, hot, whitish, dense.	white dwarf
Dimmer and smaller than a white dwarf with a density similar to that of nuclei; too dim to show on a Hertzsprung–Russell diagram.	neutron star
The end point of most massive stars.	black hole

25.3

1 inward gravitational, outward radiation
2 density
3 temperature
4 reddish
5 energy
6 temperature
7 hydrogen
8 hydrogen, helium