M1. (a) concentration / tiredness / drugs / alcohol

accept any reasonable factor that could affect a driver's reactions

*do **not** accept speed or any physical condition unrelated to the driver*

1

(b) 31.25

*credit for **1** mark correct attempt to calculate the area under the slope **or** for using the equation*
distance = <u>average</u> velocity (speed) × time

*credit for **1** mark use of correct velocity change (12.5) <u>and</u> correct time (5) **or** answer of 62.5*

3

(c) 2.5

*credit for **1** mark triangle drawn on slope **or** correct equation **or** two correct pairs of coordinates*

credit for 1 mark use of correct velocity change (12.5) and correct time (5)
accept time = between 4.8 and 5.2 if used in (b)

do not accept an attempt using one pair of coordinates taken from the slope

3

metres / second / second **or** metres / second / squared **or** m/s^2 **or** ms^{-2}

1

(d) (i) force = mass × acceleration

accept correct transformation

accept F = m × a

accept 

provided subsequent use of Δ is correct

*do **not** accept an equation in units*

1

(ii) 2250

credit their (c) × 900 for 2 marks

*credit **1** mark for correct substitution*

2

[11]

M2.(a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)

*do **not** accept region*

1

(iii) starts at same y−intercept

1

steeper slope than original and cuts time axis before original

the entire line must be below the given line

allow curve

1

(c) (i) 31

and

31

*correct answers to 2 significant figures gains **3** marks even if no working shown*

*both values to more than 2 significant figures gains **2** marks:*
30.952…...
30.769….

65 / 2.1 and / or
*80 / 2.6 gains **1** mark*

*if incorrect answers given but if both are to 2 significant figures allow **1** mark*

3

(ii) student 1 incorrect because 80 ≠ 65

1

student 2 correct because average velocities similar

*ecf from **(c)(i)***

1

student 3 incorrect because times are different

1

[12]

M3.(a) more streamlined

accept decrease surface area

1

air resistance is smaller (for same speed)

accept drag for air resistance

friction is insufficient

1

so reaches a higher speed (before resultant force is 0)

ignore reference to mass

1

(b) (i) 1.7

*allow **1** mark for correct method, ie* $\frac{5}{3}$

***or** allow **1** mark for an answer with more than 2 sig figs that rounds to 1.7*

***or** allow **1** mark for an answer of 17*

2

(ii) 7.5

*allow **1** mark for correct use of graph, eg* $\frac{1}{2} \times 5 \times 3$

2

(iii) air (resistance)

accept wind (resistance)

drag is insufficient

friction is insufficient

1

[8]

M4. (a) Throughout the question the equation M = mv is credited once only. This is the first time it appears. The mark scheme below assumes it will appear in (i).

(i) M = mv m × v sufficient **not** m × s, mass × speed

= 1500 × 8

= 12 000

(see marking of calculations)

3

(ii) M = mv

M = 2000 × 1 = 2000

(see marking of calculations)

2

(iii) must be sum of (i) and (ii) 14 000

for 1 mark

1

(b) total mass = 3500
momentum = 14 000 (conserved)
M = mv **or** v = 14 000/3500
v = 4
m/s

5

(c) (i) it reduces

for 1 mark

1

(ii) ke to sound/heat

for 1 mark

1

(iii) change smaller

for 1 mark

1
[14]

M5.(a) amplitude = 8 (cm)

1

period = 4(s)

1

(b) (i) same reading error for 10 swings as 1 swing

1

so reduces (%) error in timings**or**reduces error in an individual time period

accept it makes timing errors less significant

accept increases reliability / precision

ignore increases accuracy

1

(ii) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response.

0 marks No relevant content

Level 1 (1–2 marks)
There is a basic description of the experimental steps but no correct reference to dps or sfs.

Level 2 (3–4 marks)
There is a clear description of the experimental steps and correct reference to either dps or sfs

Level 3 (5–6 marks)
There is a clear and detailed description of the experimental steps and correct reference to both dps and sfs

examples of the physics points made in the response

- measure the length of the pendulum with a ruler
- pull the bob to one side, measure the angle of release and release the pendulum bob
- time 10 swings / oscillations
- change the length of the pendulum and repeat
- divide each recorded time by 10
- number of decimal places for raw data depends on resolution of measuring device
- number of sf for Time period (1.80) depends on number of sfs for time for 10 swings (18.0)

6

(iii) as the length of the pendulum increases the time period increases, and this relationship is non-linear

*do **not** accept they are directly proportional*

1

the time period does not depend on the mass of the pendulum bob or the angle of release

1

or

there is no relationship between either the mass of the pendulum bob or the angle of release and the time period

a specific statement illustrating that the conclusions are only valid within the limits of experimental uncertainty

eg there are always random uncertainties within any experiment. For Table 2 data repeating the experiment 5 times for the same mass of pendulum bob, you would expect a small variation in times between 20.0 s and 20.3 s.

1

or

a statement that the conculsions are only valid within the ranges measured for each variable

(c) No

time period does not change / always 4 seconds because

1

frequency is constant / frequency is related to period (T =1 /f) and hence if period is constant frequency will be constant

1

[15]

M6.(a) (i) turning

accept turning ringed in the box

1

(ii) point at which mass (or weight) may be thought to be concentrated

accept the point from which the weight appears to act

allow focused for concentrated

*do **not** accept most / some of the mass*

*do **not** accept region / area for point*

1

(b) 600 (Nm)

*400 × 1.5 gains **1** mark provided no subsequent steps shown*

2

(c) (i) plank rotates clockwise

accept girl moves downwards

*do **not** accept rotates to the right*

1

(total) CM > (total) ACM

accept moment is larger on the girl's side

1

weight of see-saw provides CM

answer must be in terms of moment

*maximum of **2** marks if there is no reference to the weight of the see-saw*

1

(ii) W = 445 (N)

*W × 1.5 = (270 × 0.25) + (300 × 2.0) gains **2** marks*

*allow for **1** mark:*

total CM = total ACM either stated or implied

or

(270 × 0.25) + (300 × 2.0)

if no other marks given

3

[10]

M7.(a) increases

1

(b) (i) **B**

1

(ii) tension in the wire

1

(iii) **C**

1

[4]

(a) (i) liquids are (virtually)

incompressible

1

(b) 84

*allow **1** mark for correct substitution, ie*

$$1.5 \times 10^{6} = \frac{F}{5.6 \times 10^{-5}}$$

numbers may not be written in standard form, ie

$$1\,500\,000 = F \quad \frac{F}{0.000\,056}$$

*allow **1** mark for an answer 216*

2

(c) it (the force on the slave pistons) is greater / larger

accept force (at slave piston) = 216 (N)

1

the area (touching the liquid) of the slave piston is greater than the area of the master piston

accept it has a bigger area

just quoting numbers, eg the master piston is 5×10^{-5} and the slave piston is 14.4×10^{-5} is insufficient

1

[5]

(a) (i) dispersion

1

(ii) violet green red

must be in correct order

1

(b) (i) normal

1

(ii) C

1

(iii) (n =) sin i / sin r

1

same i

1

different r for different colours **or**

(n =) speed in air / speed in glass (1)

same speed in air (1)

different speeds in glass for

different colours (1)

different colours show different amounts of refraction

1

(c) (i) *Refractive index* increases as *wavelength* decreases

accept converse

allow negative correlation

allow inversely proportional

1

(ii) $1.980\ldots \times 10^{8}$ (m / s)

198019802

Accept any correct rounding

2.0×10^{8} 2×10^{8}

*allow **1** mark for correct substitution*

$1.515 = 3 \times 10^{8}$ / speed of light in glass

2

(d) need separate colours

emits white light is insufficient on its own

1

can't measure angles with enough precision / resolution/ detail

ignore accuracy

1

(e) (i) reflection

*do **not** accept refraction*

1

total internal (reflection)

*do **not** accept refraction*

1

angle of incidence (within glass)

*do **not** accept reference to air*

1

greater than critical angle

1

(ii) 41.10(66…)°

accept 41, 41.1

*allow **1** mark for correct substitution ie 1.521 = 1 / sin C*

*allow **2** marks for correct substitution ie sin C = 0.657*

3

[19]

M10.(a) 10^{-15} metres to 10^{4} metres

1

(b) (i) any **one** from:

- (TV / video / DVD) remote controls

mobile phones is insufficient

- (short range) data transmission
  accept specific example, eg linking computer peripherals

- optical fibre (signals)
  *do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*
*an answer given to more than 2 significant figures that rounds to 0.17 gains **2** marks*
*allow **1** mark for correct substitution, ie* $3 \times 10^{8} = 1.8 \times 10^{9} \times \lambda$

3

(c) (maybe) other factors involved

accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age
not testing enough people is insufficient
unreliable data is insufficient

1
[6]

M11.(a) because the angle of incidence is greater than critical angle

accept the light is totally internally reflected

1

(b) 41.8

*allow **1** mark for correct substitution, eg* $1.5 = \frac{1}{\sin c}$
or
$\sin c = \frac{1}{1.5}$
or
$c = \sin^{-1}\frac{1}{1.5}$

2

(c) (for both fibres) increasing the <u>wavelength</u> of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*
(for both fibres) increasing the <u>wavelength</u> (of light) to 5 (x 10^{-7} *metres), decreases the (percentage) transmission*

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)
or
maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*
(for both fibres) increasing the <u>wavelength</u> of the light from 5 (x 10^{-7} *metres) increases the amount of light transmitted*
increasing <u>wavelength</u> (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark: Any statement that correctly*

processes data to compare the fibres

1

[6]

M12.(a) (i) 20

1

20 000

either order

accept ringed answers in box

1

(ii) (frequency) above human range

accept pitch for frequency

or

(frequency) above 20 000 (Hz)

*do **not** accept outside human range*

*allow ecf from incorrect value in **(a)(i)***

1

(iii) any **one** from:

- pre-natal scanning

  accept any other appropriate scanning use

  *do **not** accept pregnancy testing*
- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle

  accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation

  accept physiotherapy

  accept curing prostate cancer or killing prostate cancer cells
- removing plaque from teeth

  cleaning teeth is insufficient

1

(b) 7.5×10^{-4} (m)

*$1.5 \times 10^{3} = 2.0 \times 10^{6} \times \lambda$ gains **1** mark*

2

(c) for reflected waves

must be clear whether referring to emitted or detected / reflected waves

if not specified assume it refers to reflected wave

any **two** from:

- frequency decreased
- wavelength increased
- intensity has decreased

  allow amplitude / energy has decreased
  allow the beam is weaker

2

[8]

.(a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

ultraviolet cannot be seen is insufficient

- (ultraviolet has a) greater energy
- (ultraviolet has a) shorter wavelength

ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*
*answers 12 000 kHz **or** 12 MHz gain **3** marks*
for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)
accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

M14.(a) there are strong forces (of attraction) between the particles in a solid

accept molecules / atoms for particles throughout
accept bonds for forces

1

(holding) the particles close together

particles in a solid are less spread out is insufficient

1

or

(holding) the particles in a fixed pattern / positions

but in a gas the forces between the particles are negligible

accept very small / zero for negligible

accept bonds for forces

1

so the particles spread out (to fill their container)

accept particles are not close together
gas particles are not in a fixed position is insufficient

1

(b) (i) particles are (shown) leaving (the liquid / container)

accept molecules / atoms for particles throughout

accept particles are escapingparticles are getting further apart is insufficient

1

(ii) *accept molecules / atoms for particles throughout*
accept speed / velocity for energy throughout

particles with most energy leave the (surface of the) liquid

accept fastest particles leave the liquid

1

so the mean / average energy of the remaining particles goes down

1

and the lower the average energy (of the particles) the lower the temperature (of the liquid)

1

[8]

M15.(a) conduction

1

(b) 35 000

1

(c) 500

*their (b) = 2 x c x 35 correctly calculated scores **2** marks*

*allow **1** mark for correct substitution,*

ie 35000 = 2 x c x 35

or

their (b) = 2 x c x 35

2

J / kg°C

1

(d) energy lost to surroundings

or

energy needed to warm heater

accept there is no insulation (on the copper block)

*do **not** accept answers in terms of human error or poor results or defective equipment*

1

[6]

M16.(a) (matt) black is a good emitter of infrared / radiation

accept heat for infrared / radiationignore reference to good absorberattracts heat negates this marking point

1

to give maximum (rate of) energy transfer (to surroundings)

accept temperature (of coolant) falls fast(er)

*accept black emits more radiation for **1** mark*

*black emits most radiation / black is the best emitter of radiation for **2** marks*

1

(b) the fins increase the surface area

accept heat for energy

1

so increasing the (rate of) energy transfer**or**so more fins greater (rate of) energy transfer

1

(c) 114 000

*allow **1** mark for correct temperature change, ie 15 (°C)*

or

*allow **2** marks for correct substitution, ie 2 × 3 800 × 15*

*answers of 851 200 **or** 737 200 gain **2** marks*

or

*substitution 2 × 3800 × 112 **or** 2 × 3800 × 97 gains **1** mark*

*an answer of 114 kJ gains **3** marks*

3

(d) increases the efficiency

1

less (input) energy is wasted

accept some of the energy that would have been wasted is (usefully) used

or

more (input) energy is usefully used

accept heat for energy

1

[9]

M17. (a) any **two** from:

- (air) particles / molecules / atoms gain energy
- (air) particles / molecules / atoms move faster

  *do **not** accept move more*

  *do **not** accept move with a bigger amplitude / vibrate more*
- (air) particles / molecules / atoms move apart
- air expands

  ignore particles expand
- air becomes less dense

  ignore particles become less dense
- warm / hot air / gases / particles rise

  *do **not** accept heat rises*

  answers in terms of heat particles negates any of the mark points that includes particles

2

(b) (i) any **two** from

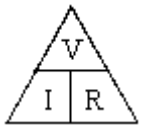
- free / mobile electrons gain (kinetic) energy
  accept free / mobile electrons move faster
  accept vibrate faster for gain energy
- free electrons collide with other (free) electrons / ions / atoms / particles
- atoms / ions / particles collide with other atoms / ions / particles
  answers in terms of heat particles negates this mark point

2

(ii) (faster) energy / heat transfer to room(s) / house
accept room(s) / house gets warm(er)
accept lounge / bedroom / loft for rooms

1
[5]

M18. (a) (i) potential difference = current × resistance
*accept voltage **or** pd for potential difference*
accept $V = I \times R$
accept correct transformation
*do **not** accept $V = C \times R$*
*do **not** accept $V = A \times R$*

accept 

provided

subsequent use of Δ correct
*do **not** accept an equation expressed in units*

1

(ii) 46
*credit correct transformation for **1** mark*
allow 1 mark for use of 11.5 V or division of final resistance by 20
*a final answer of 920 gains **2** marks only*

3

ohm(s)
accept symbol Ω
*do **not** accept Ω s*
unit / symbol mark can be awarded in (iii) provided unit / symbol is omitted in (ii)

1

(iii) 920 (ohms) **or** their (a)(ii) × 20

1

(b) as temperature increases, resistance increases
accept hotter for temperature increase
*do **not** accept a reference to resistance only i.e. it / resistance goes up*

1
[7]

M19. (a) *Formula mark*
P = V × I
*accept P = VI **or** W = V 5 A **or** any transformation*
1

Substitution mark I = 900 ÷ 230
1

Calculation mark 3.9
*accept 3.9 **or** 3.91 **or** 4 for three marks with no working*
1

(b) 900 + 1300 = 2200 ÷ 230 = 9.6
*accept 9.57 to 9.6 **or** 10 for both marks with no working*
2

(c) 1.2 + 0.45 = 1.65
1

× 0.5 = 0.825
*accept 0.8 **or** 0.83 for both marks with no working*
1

(d) any **one** from

use less energy (to cook something)
*accept fewer energy losses **or** use less electricity*

cook faster
do not credit a cost argument about buying two different ovens
1
[8]

M20. (a) series circuit
all four components must be included
if a battery included the neatness mark may still be awarded
1

circuit fully functional **or** properly connected
this is the neatness mark
do not credit a parallel circuit with one switch controlling both components
1

(b) case **or** outer parts are made of plastic **or** insulator **or** non-metallic
1

there is no electrical pathway between inner and outer insulation
accept no connection between inner and outer part
do not credit two layers of insulation
1

(c) (i) [A] power = voltage × current
*accept P = V I **or***
W = V × A
***or** any transformation*
1

[B] 1600 ÷ 230 =current
1

6.96 **or** 7
accept with no working for two marks
accept 6.95
in [A] award a mark for a triangle if calculation correctly performed
1

(ii) [A] voltage = current × resistance
*accept V = I R **or** any transformation*
1

[B] 230 ÷ 7 = overall R = 33
accept 230 ÷ 6.96 = overall R = 33
1

resistance of motor = 33 – 20 = 13
accept with no working for two marks
do not credit negative answer
accept consequential errors from c(i)
in [A] award a mark for a triangle if calculation correctly performed
1
[10]

M21. (a) (i) spilling boiling / hot water
accept any sensible suggestion
1

suitable precaution to reduce risk from hot water eg

clamp the probe / complete the experiment standing
accept any sensible answer but must be linked to the named risk
1

(ii) 3 (V)
*allow **1** mark for substitution into correct equation*
ie 0.5 × 6
2

(b) (i) resistance of thermistor decreases
1

therefore the current in the circuit increases
1

causing a bigger share of the p.d. across 6 Ω resistor
1

(ii) 0 – 100 (°C)
accept 10° – 100°C
1

(iii) 20°C to 40 °C
1

because a small temperature change gives a bigger voltmeter reading change
1

(c) thermostat
accept a correct description of a use

1
[11]

M22. (a) (i) it moves or experiences a force horizontally to the right
for 1 mark
1

(ii) A – moves in opposite direction or force reversed e.c.f.
B – faster movement or larger force
(**not** move further)
for 1 mark each
2

(b) turns clockwise
oscillates/reverses
comes to rest facing field/at 90° to field/vertically
for 1 mark each
3

(c) number of turns or linear number density of turns current core
for 1 mark each
3
[9]

M23. (i) iron
for 1 mark
1

(ii) 20
gains 2 marks

else working
gains 1 mark
2

(iii) reverse input/output
for 1 mark

or increase secondary turns
1
[4]

M24. (a) **Y** and **Z**
both required, either order
1

same number of protons
1

(b) fusion
correct order only
1

energy
1

(c) Marks awarded for this answer will be determined by the

Quality of Written Communication (QWC) as well as the standard of the scientific response.

No relevant content.

0 marks

There is a brief description of the life cycle of a star like the sun.

Level 1 (1–2 marks)

There is some description of the life cycle of a star like the sun.

Level 2 (3–4 marks)

There is a clear and detailed description of the life cycle of a star like the sun.

Level 3 (5–6 marks)

examples of the physics points made in the response

*to score full marks either the term red giant or white dwarf **must** be used*

- gases and dust pulled together by gravity
- nuclear fusion begins
- when forces are balanced star is stable
- expands
- cools
- becomes a red giant

  *do **not** accept red supergiant*
- shrinks
- temperature rises
- glows much brighter
- becomes a white dwarf

  any mention of supernova negates a mark
  any mention of black hole negates a mark

individual points must be linked in a correct sequence

[10]

M25.(a) uranium-235

accept any correct indication

1

(b) splits / breaks (into two smaller parts)

nucleus is separated is insufficient

*do **not** accept atom splits – on its own*

1

and (two / three) neutrons

1

(c) steam

correct order only

1

turbine

1

generator

1

[6]

M26. (a) (i) 3 fewer neutrons

accept fewer neutrons

accept different number of neutrons

*do **not** accept different number of electrons*

1

(ii) electron from the nucleus

both points needed

1

(iii) 32 (days)

*allow **1** mark for clearly obtaining 4 half-lives*

2

(iv) has a **much** longer half-life

accept converse answers in terms of iodine-131

accept it has not reached one half-life yet

1

little decay happened / still in the atmosphere

accept it is still decaying

1

(b) any **two** from:

marks are for reasons

- some children developed TC before 1986
- some children (after 1986) that developed TC did not live in highly contaminated areas
- the (large) increase can (only) be explained by (a large increase in) radiation as caused by Chernobyl
- all areas would be contaminated (and raise the risk of TC)
- no evidence (of effect) of other variables

2

(c) People not exposed (to the radiation but who were otherwise similar)

accept people not affected (by the radiation)

1

(d) any **two** from:

*answers should be in terms of nuclear power and **not** why we should not use other fuels*

- produce no pollutant / harmful gases

accept named gas or greenhouse gases

*do **not** accept no pollution*

- produces a lot of energy for a small mass (of fuel) **or**
  is a concentrated energy source
  accept amount for mass
  accept high energy density

- it is reliable **or**
  it can generate all of the time

- produces only a small volume of (solid) waste
  accept amount for volume

2
[11]

M27. (a) indication (in writing or on graph) of finding point where radiation is halved (e.g. to 24 [from an initial 48]) and relating to the time difference between the two points
gains 1 mark

but
4.2-4.8*
(*i.e. in this range, including extremes)
gains 2 marks

units billions of years
for 1 mark

3

(b) ¾ **or** 75%
[allow ecf from (a)]
for 1 mark

1

(c) (i) *idea that* the intermediate nuclides are relatively short-lived
for 1 mark

1

(ii) *idea that* ¼ has decayed **or** ¾ remains
gains 1 mark

but
read graph for radiation level of 36 (stated or shown on graph itself)
gains 2 marks

but
1.6-1.8* (billion years)
(* i.e. in this range, including extremes)
gains 3 marks

3
[8]