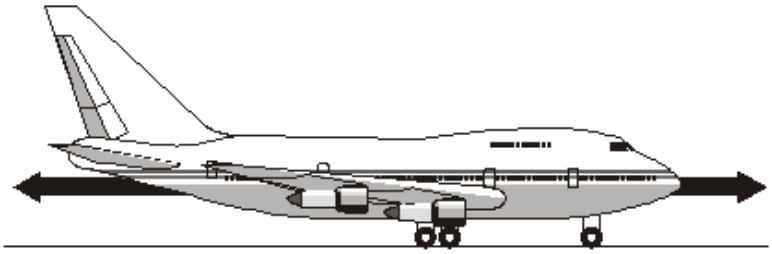
Q1. (a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.



(i) What is meant by the term *resultant force*?

.....

.....

(1)

(ii) Describe the movement of the aircraft when the resultant force is zero.

.....

.....

(1)

(b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Use the equation in the box to calculate the maximum acceleration of the aircraft.

resultant force = mass × acceleration

Show clearly how you work out your answer and give the unit.

.....

.....

.....

Acceleration = ...

(3)

(c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

.....

.....

.....

.....

(2)

(Total 7 marks)

Q2. (a) The stopping distance of a vehicle is made up of two parts, the thinking distance and the braking distance.

(i) What is meant by *thinking distance*?

.....

.....

(1)

(ii) State **two** factors that affect thinking distance.

1 .....

.....

2 .....

.....

(2)

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

Kinetic energy = ... J

(2)

(ii) How much work is done by the braking force to stop the car and driver?

Work done = ... J

(1)

(iii) The braking force used to stop the car and driver was 8000 N.

Calculate the braking distance of the car.

Use the correct equation from the Physics Equations Sheet.

.....

.....

.....

.....

Braking distance = ... m

(2)

(iv) The braking distance of a car depends on the speed of the car and the braking force applied.

State **one** other factor that affects braking distance.

.....

.....

(1)

(v) Applying the brakes of the car causes the temperature of the brakes to increase.

Explain why.

.....

.....

.....

.....

(2)

(c) Hybrid cars have an electric engine and a petrol engine. This type of car is often fitted with a regenerative braking system. A regenerative braking system not only slows a car down but at the same time causes a generator to charge the car's battery.

State and explain the benefit of a hybrid car being fitted with a regenerative braking system.

.....

.....

.....

.....

.....

.....

(3)
(Total 14 marks)

Q3. The diagram shows the horizontal forces acting on a car of mass 1200 kg.

(a) Calculate the acceleration of the car at the instant shown in the diagram.

Write down the equation you use, and then show clearly how you work out your answer and give the unit.

.....

.....

.....

.....

.....

.....

.....

.....

Acceleration = ...

(4)

(b) Explain why the car reaches a top speed even though the thrust force remains constant at 3500 N.

.....

.....

.....

.....

.....

.....

(3)

(c) The diagram shows a car and a van.

The two vehicles have the same mass and identical engines.

Explain why the top speed of the car is higher than the top speed of the van.

.....

.....

.....

.....

.....

.....

.....

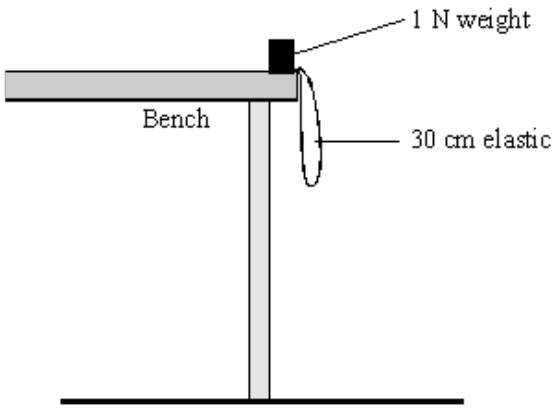
.....

.....

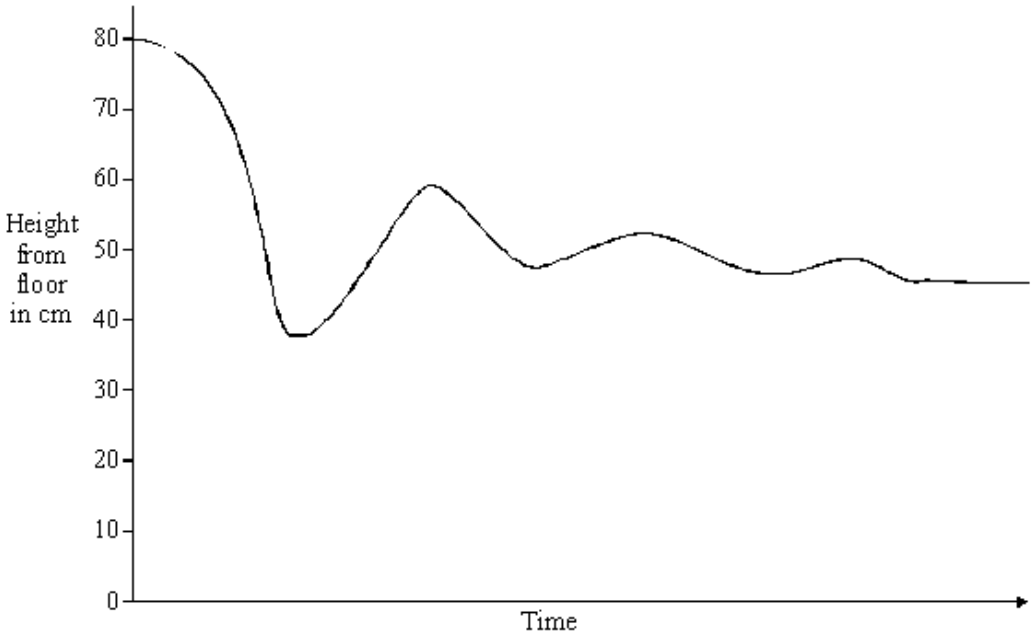
.....

(4)
(Total 11 marks)

Q4. A 1 N weight is tied to a 30 cm long piece of elastic. The other end is fixed to the edge of a laboratory bench. The weight is pushed off the bench and bounces up and down on the elastic.



The graph shows the height of the weight above the floor plotted against time, as it bounces up and down and quickly comes to rest.



(a) Mark on the graph a point labelled **F**, where the weight stops falling freely.

(1)

(b) Mark on the graph a point labelled **S**, where the weight finally comes to rest.

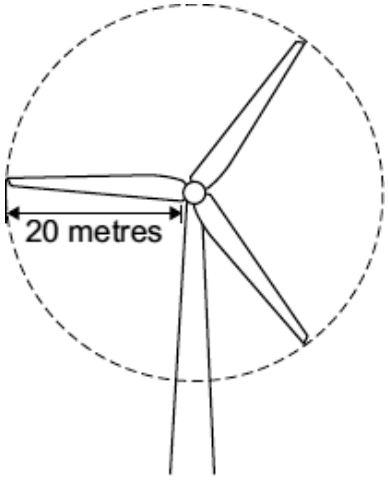
(1)

(c) Mark **two** points on the graph each labelled **M**, where the weight is momentarily stationary.

(1)

(Total 3 marks)

Q5. The diagram shows a wind turbine.



(a) The blades of the turbine are 20 metres long. On average, 15 000 kg of air, moving at a speed of 12 m/s, hit the blades every second.

Use the equation in the box to calculate the kinetic energy of the air hitting the blades every second.

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$$

Show clearly how you work out your answer.

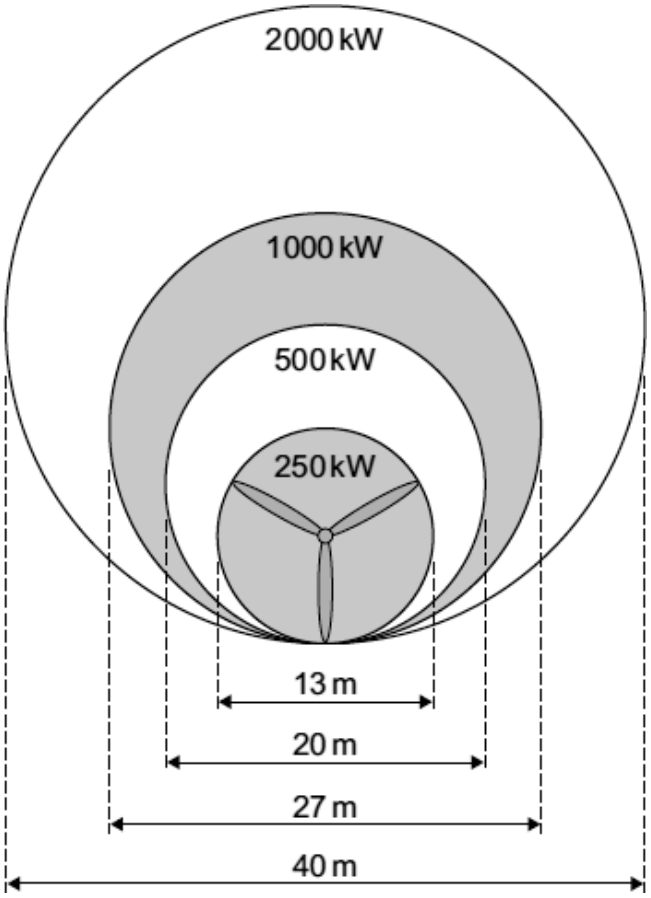
.....

.....

Kinetic energy = ... J

(2)

(b) Part of the kinetic energy of the wind is transformed into electrical energy.
The diagram shows that, for the same wind speed, the power output of a turbine, in kilowatts, depends on the length of the turbine blades.



Give a reason why doubling the diameter of the blades more than doubles the power output of a turbine.

.....

.....

(1)
(Total 3 marks)

Q6. (a) In any collision, the total momentum of the colliding objects is usually conserved.

(i) What is meant by the term 'momentum is conserved'?

.....

.....

(1)

(ii) In a collision, momentum is **not always** conserved.

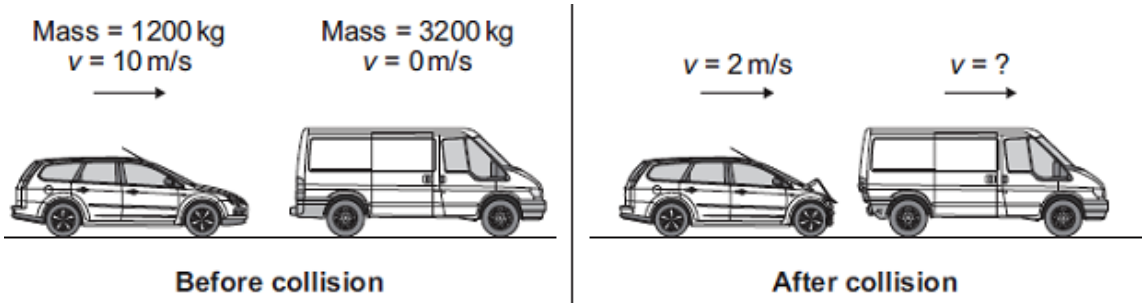
Why?

.....

.....

(1)

(b) The diagram shows a car and a van, just before and just after the car collided with the van.



(i) Use the information in the diagram and the equation in the box to calculate the **change** in the momentum of the car.

momentum = mass x velocity

Show clearly how you work out your answer and give the unit.

.....

.....

.....

.....

Change in momentum = ...

(3)

(ii) Use the idea of conservation of momentum to calculate the velocity of the van when it is pushed forward by the collision.

Show clearly how you work out your answer.

.....

.....

.....

Velocity = ... m/s forward

(2)
(Total 7 marks)

Q7. (a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

.....

(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

.....

.....

(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

.....

(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

.....

Give a reason for your answer.

.....

.....

(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

.....

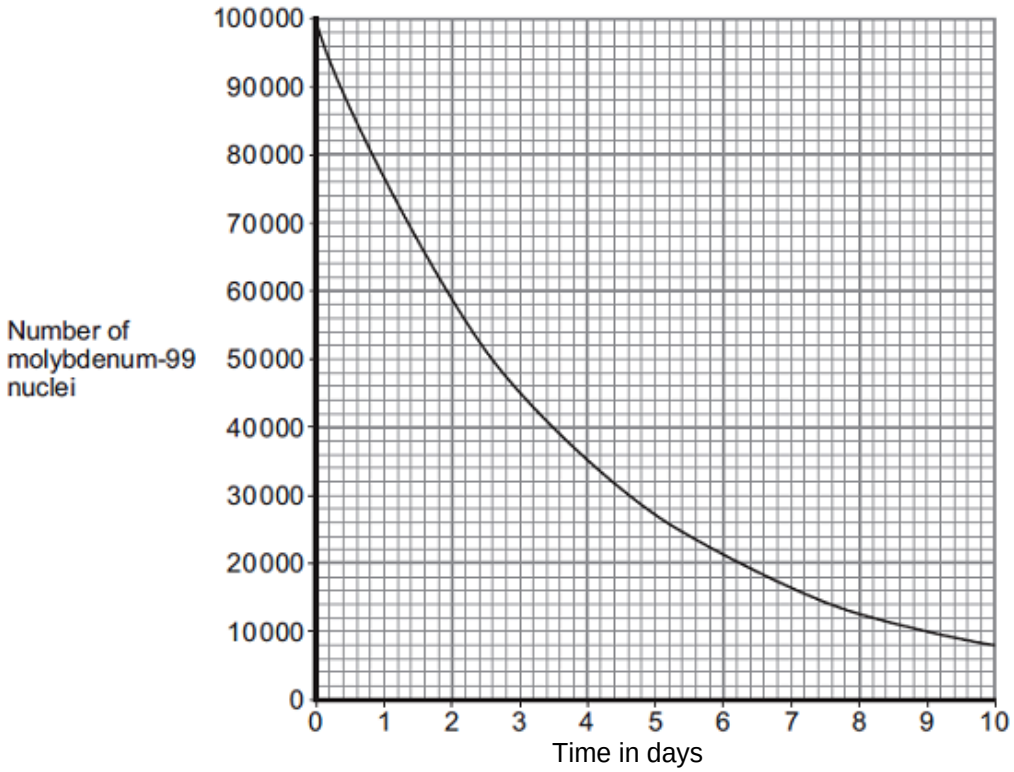
.....

.....

(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

.....

.....

.....

Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

.....

.....

.....

.....

(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

.....

.....

(1)

(Total 11 marks)

Q8. In 2011 an earthquake caused severe damage to a nuclear power station in Japan.

The damage led to the release of large amounts of radioactive iodine-131 ($^{131}_{53}I$) into the atmosphere.

(a) The table gives some information about an atom of iodine-131 ($^{131}_{53}I$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1)

(b) Complete the sentence.

The number of protons in an atom is called the proton number or

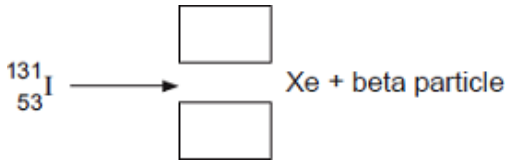
the ..... number.

(1)

(c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

(i) The decay of iodine-131 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.



(2)

(ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

.....

.....

..... days

(2)

(iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

.....

.....

.....

.....

(2)

(Total 8 marks)

M1. (a) (i) a single force that has the same effect as all the forces combined

accept all the forces added / the sum of the forces / overall force

1

(ii) constant speed (in a straight line)

*do **not** accept stationary*

or constant velocity

1

(b) 3

*allow **1** mark for correct substitution into transformed equation*
*accept answer 0.003 gains **1** mark*
*answer = 0.75 gains **1** mark*

2

m/s^2

1

(c) as speed increases air resistance increases

accept drag / friction for air resistance

1

reducing the resultant force

1

[7]

M2. (a) (i) distance vehicle travels during driver's reaction time

accept distance vehicle travels while driver reacts

1

(ii) any **two** from:

- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age

accept as an alternative factor distractions, eg using a mobile phone

2

(b) (i) 320 000

*allow **1** mark for correct substitution, ie* $\frac{1}{2} \times 1600 \times 20^2$ *provided no subsequent step shown*

2

(ii) 320000 **or** their (b)(i)

1

(iii) 40

or

$\frac{\text{their (b)(ii)}}{8000}$ correctly calculated

*allow **1** mark for statement work done = KE lost*

or

*allow **1** mark for correct substitution, ie*
*8000 × distance = 320 000 **or** their (b)(ii)*

2

(iv) any **one** from:

- icy / wet roads
  accept weather conditions
- (worn) tyres
- road surface
- mass (of car and passengers)
  accept number of passengers
- (efficiency / condition of the) brakes

1

(v) (work done by) friction
(between brakes and wheel)

*do **not** accept friction between road and tyres / wheels*

1

(causes) decrease in KE and increase in thermal energy

accept heat for thermal energy accept
KE transferred to thermal energy

1

(c) the battery needs recharging less often

accept car for battery

1

or

increases the range of the car

*accept less demand for other fuels **or** lower emissions **or** lower fuel costs*
environmentally friendly is insufficient

as the efficiency of the car is increased

accept it is energy efficient

1

the decrease in (kinetic) energy / work done charges the battery (up)

accept because not all work done / (kinetic) energy is wasted

1

[14]

M3. (a) 1.25

*allow **1** mark for correct resultant force ie 1500N*

*allow **2** marks for correct transformation and substitution*

ie $\frac{1500}{1200}$

*allow **1** mark for a correct transformation but clearly substituting an incorrect value for force*

eg = $\frac{3500}{1200}$

3

m/s^2

1

(b) as speed increases so does the size of the drag force

accept frictional force / resistive force / air resistance for drag

1

eventually the drag force becomes equal to the thrust

1

the resultant force is now equal to zero and therefore there is no further acceleration

1

(c) the car and van will reach top speed when the forward force equals the drag force

accept air resistance / frictional / resistive force for drag force

1

the drag force at any speed is smaller for the car than for the van

1

as the car is more streamlined

1

therefore the car's drag force will equal the forward force at a higher speed

1

allow converse throughout

[11]

M4. (a) **F** 50 cm on first part of graph

*tolerance + **or** – 3cm*

1

(b) **S** at the far right

credit anywhere to right of last trough

1

(c) **M** on any two tops of peaks **or** bottoms of troughs

both are required for the mark M needs to be central to the trough
***or** peak, except if F is in the way in one case*

1

[3]

M5. (a) 1 080 000

*allow **1** mark for correct substitution*
ie ½ × 15 000 × 12 × 12

2

(b) any **one** from:

- KE (of wind) more than doubles
- mass of air (hitting blades) more than doubles
- area swept out by blades more than doubles

  *do **not** accept blades are larger / have a bigger area*
- area swept out by blades increases × 4

1

[3]

M6. (a) (i) momentum before = momentum after

accept no momentum is lost
accept no momentum is gained

or
(total) momentum stays the same

1

(ii) an external force acts (on the colliding objects)

accept colliding objects are not isolated

1

(b) (i) 9600

allow 1 mark for correct calculation of momentum before or after ie 12000 or 2400
or
correct substitution using change in velocity = 8 m/s
ie 1200 × 8

2

kg m/s
or
Ns

this may be given in words rather than symbols
*do **not** accept nS*

1

(ii) 3 or their (b)(i) ÷ 3200 correctly calculated

allow 1 mark for stating momentum before = momentum after

or

clear attempt to use conservation of momentum

2

[7]

M7. (a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:

- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

M8. (a) 78

1

(b) atomic

1

(c) (i) 131

correct order only

1

54

1

(ii) 32 (days)

*allow **1** mark for showing 4 half-lives provided no subsequent step*

2

(iii) limits amount of iodine-131 / radioactive iodine that can be absorbed

accept increases level of non-radioactive iodine in thyroid

*do **not** accept cancels out iodine-131*

1

so reducing risk of cancer (of the thyroid)

accept stops risk of cancer (of the thyroid)

1

[8]