Name: _____

Force & Motion

Date:

Time: 1 hour

Total marks available: 60

Total marks achieved: _____

Questions

Q1.

In a science fiction story, lightning is used as an energy source for accelerating a car.

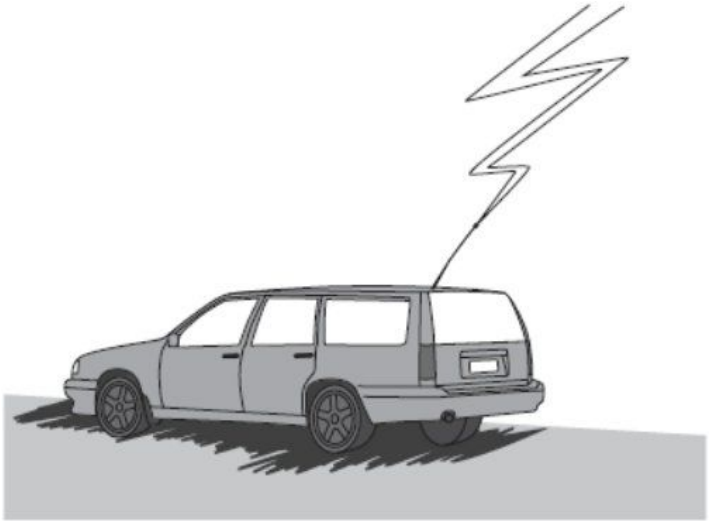


Figure 6

In the story, the car has a kinetic energy of 960 kJ at a speed of 40 m/s.

(i) Calculate the mass of the car.

(4)

mass = ... kg

(ii) Only 5% of the energy of the lightning bolt is transferred to the kinetic energy of the car.
Calculate the total energy of the lightning bolt in MJ.

(2)

energy = ... MJ

(Total for question = 6 marks)

Q2.

Figure 13 shows two ice skaters during a performance.

Figure 13

(i) The two ice skaters are travelling together in a straight line at 3.50 m/s.
Their total momentum is 371 kgm/s.
The man has a mass of 64.5 kg.
Calculate the mass of the woman.

(4)

mass = ... kg

(ii) Calculate the kinetic energy of the man.

(2)

kinetic energy = ... J

(Total for question = 6 marks)

Q3.

Figure 12 shows a skier on a slope.
The skier travels down the slope with a constant acceleration.
The speed of the skier is measured at points P and Q.

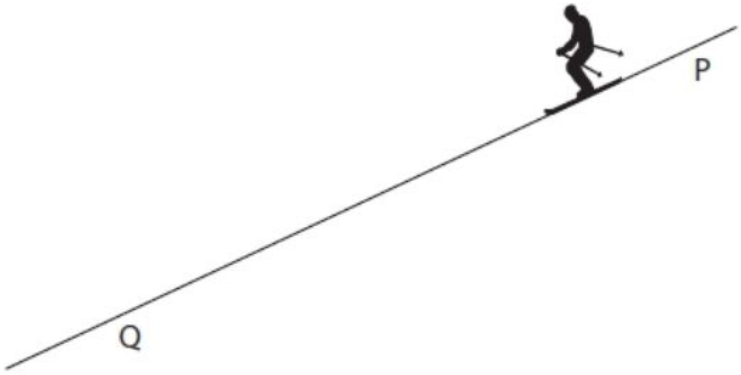


Figure 12

The table in Figure 13 gives some data about the skier making one downhill run.

acceleration	3.0 m/s^2
speed at P	7.6 m/s
speed at Q	24 m/s

Figure 13

(i) Calculate the distance from P to Q.
Use an equation selected from the list of equations at the end of this paper.

(3)

distance from P to Q = ... m

(ii) Calculate the time taken for the skier to travel from P to Q.

(3)

time from P to Q = ... s

(Total for question = 6 marks)

Q4.

Figure 3 is a velocity-time graph for the motion of a van on a long, straight road.

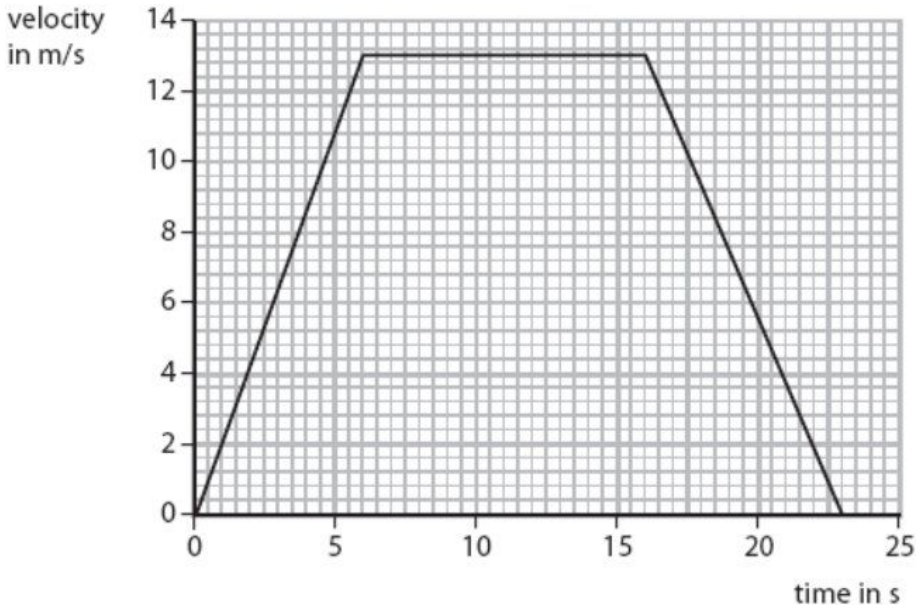


Figure 3

(i) The van accelerates at 2.2 m/s^2.

The force causing this acceleration is 5.5 kN.
Calculate the mass of the van.

(3)

mass = ... kg

(ii) Calculate the distance travelled by the van between 16.0 s and 23.0 s.

Give your answer correct to 2 significant figures.

(4)

distance travelled = ... m

(Total for question = 7 marks)

Q5.

A car travelling at 15 m/s comes to rest in a distance of 14 m when the brakes are applied.

Calculate the deceleration of the car.
Use an equation selected from the list of equations at the end of this paper.

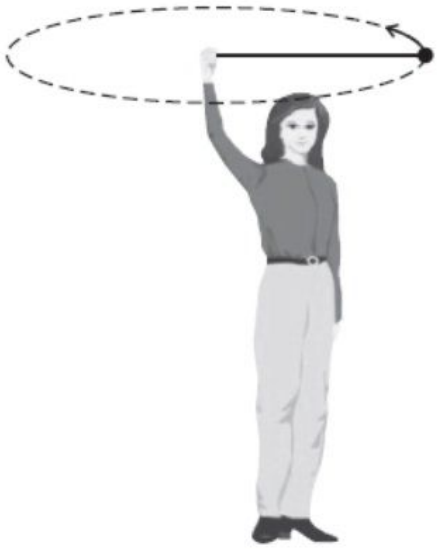
(3)

deceleration = ... m/s^2

(Total for question = 3 marks)

Q6.

(a) The diagram shows a girl swinging a rubber ball in a horizontal circle above her head.



(i) In which direction does the resultant force act on the ball?
Put a cross (☒) in the box next to your answer.

(1)

- ☐ **A** away from the centre of the circle
- ☐ **B** in the direction of the arrow on the diagram
- ☐ **C** in the opposite direction to the arrow on the diagram
- ☐ **D** towards the centre of the circle

(ii) State the name of the resultant force acting on the ball.

(1)

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(iii) Suggest what would happen to the ball as the girl gets tired.

(2)

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(iv) The girl lets go of the string and the ball hits a wall.
The collision is not elastic.
Explain what happens to both momentum and kinetic energy when the ball hits the wall.

(2)

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*(b) Describe a cyclotron and how charged particles move inside it.

You may draw a labelled diagram to help with your answer.

(6)

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(Total for Question = 12 marks)

Q7.

* Figure 13 shows two objects, Q and R, before and after they collide.

Figure 13

The arrows show the direction of movement of the objects.
The arrows are not to scale.

Explain how momentum is conserved in the collision.

Use Newton's third law and Newton's second law in your answer.

Newton's second law can be written as

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

(6)

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(Total for question = 6 marks)

Q8.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

The force that keeps an object moving in a circular path is known as the

(1)

- ☐ **A** balancing force
- ☐ **B** centripetal force
- ☐ **C** reaction force
- ☐ **D** resistance force

(Total for question = 1 mark)

Q9.

Figure 4 shows a car travelling on a motorway.

A passenger wants to check the accuracy of the speedometer of the car.
The car is travelling at a constant speed.
The passenger has a stopwatch.

The lamp posts are 40 m apart.

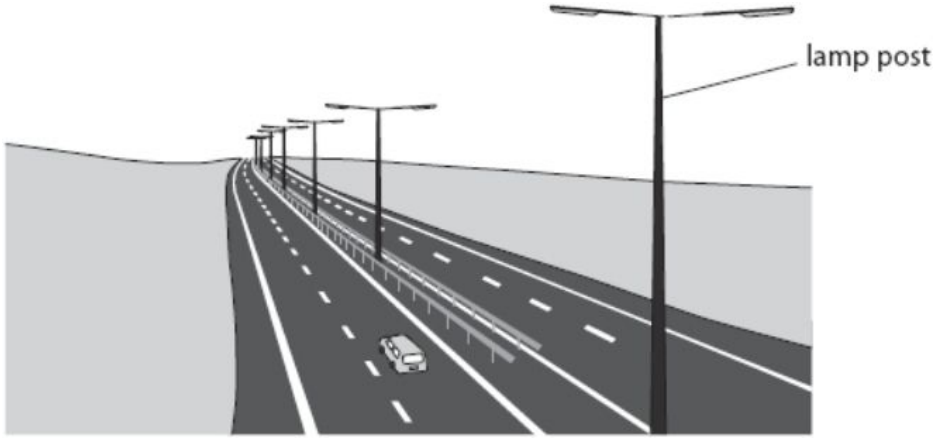

Figure 4

Describe how the passenger could determine the speed of the car as accurately as possible.

(3)

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(Total for question = 3 marks)

Q10.

Describe how the student could extend the investigation to determine the average speed of the trolley as it rolls back down the track.

(3)

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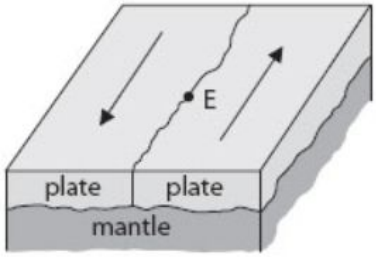
(Total for question = 3 marks)

Q11.

(a) The diagram shows part of the boundary between two tectonic plates.



(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The plates are being steadily pushed in opposite directions by

(1)

☒ **A** convection currents in the mantle

☒ **B** reflection of waves from the Earth's core

☒ **C** tsunami waves in the ocean

☒ **D** volcanic eruptions on the surface

(ii) An earthquake occurs.
Its epicentre is at the place marked E on the diagram.
Describe what happens at the plate boundary to cause this earthquake.

(2)

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(b) The earthquake causes seismic waves.

(i) S waves are one type of seismic wave. They travel at 0.65 km/s.
There is a seismometer 80 km away from point E.
Show that it takes about 2 minutes for the S waves from the earthquake to reach the seismometer.

(2)

(ii) P waves are another type of seismic wave.
They travel about 10 times more quickly than S waves.

Describe how scientists can use seismometer records of P and S waves to locate the epicentre.

(3)

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(iii) Seismic waves have a frequency of about 15 Hz.
P waves have a much smaller amplitude than S waves.

Some people claim that animals can detect an earthquake before people are aware of it.
Suggest an explanation for this.

(2)

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(Total for Question is 10 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Marks
(i)	recall K.E.= ½ m v^2(1) rearrangement (1) (m =) 2 x K.E. ÷ v^2 substitution (1) (m =) 2 x 960 000 ÷ 40^2 Evaluation (1) = 1200 (kg)	award full marks for the correct answer without working rearrangement and substitution in either order Ignore POT until evaluation	(4)

Question number	Answer	Additional guidance	Marks
(ii)	Use of efficiency equation (1) $\frac{960}{5}$ evaluation (1) =19 (MJ)	award full marks for correct numerical answer without working accept 19.2 (MJ)	(2)

Q2.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) 371 = (64.5+ m) x 3.5 rearrangement (1) m+64.5 = 371 / 3.5 evaluation of total mass (1) m+64.5 = 106 (kg) evaluation of woman's mass (1) m = 106-64.5 = 41.5 (kg)	full marks will be awarded for correct numerical answer without working	**(4)**

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) KE = ½ x 64.5 x 3.5^2 evaluation (1) 395 (J)	allow answers which round to 395 e.g. 395.0625 full marks will be awarded for correct numerical answer without working	**(2)**

Q3.

Question Number	Answer	Additional guidance	Mark
(i)	substitution in $v^2 - u^2 = 2ax$ (1) $24^2 - 7.6^2 = 2 \times 3 \times x$ rearrangement (1) $(x =) \frac{24^2 - 7.6^2}{6}$ evaluation (1) 86 (m)	accept rearrangement and substitution in either order allow numbers that round to 86 (m) award full marks for the correct answer without working	**(3)**

Question Number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) $(a = \frac{v - u}{t})$ $3.0 = \frac{24 - 7.6}{t}$ rearrangement (1) $t = \frac{v-u}{a}$ OR $(t =) \frac{24 - 7.6}{3.0}$ evaluation (1) 5.5 (s)	Allow alternative method: average speed = distance / time i.e. 15.8 = 86(.37) / time (t =) 86(.37) / 15.8 allow numbers that round to 5.5 (s) OR numbers that round to 5.4 if using alternative method and distance = 86 award full marks for the correct answer without working no marks for t = d / (v-u) = 86(.37) / (24-7.6) giving 5.3 s as an answer	**(3)**

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	rearrangement (1) (m=) $\frac{F}{a}$ substitution (1) (m=) $\frac{5500}{2.2}$ evaluation (1) 2500(kg)	Rearrangement and substitution may be in either order (m=) $\frac{5.5}{2.2}$ ignore unit conversion until evaluation POT (power of ten) error, e.g. 2.5 (kg) award 2 marks award full marks for correct numerical answer without working If no other marks scored, award one mark for a clear conversion of units	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	correctly identifies data points from the graph to calculate areas (1) use of distance = area under graph (1) substitution (1) (distance) = $\frac{(23-16)\times 13}{2}$ evaluation rounded to 2SF (1) 46 (m)	both 7 and 13 seen (distance) = $\frac{7\times 13}{2}$ (= 45.5) accept 45 (m) award full marks for correct numerical answer without working 91 scores 2 marks (incorrect area calculation using distance x time)	(4)

Q5.

Question Number	Answer	Additional guidance	Mark
	rearrangement (1) $a = \frac{(v^2-)u^2}{2x}$ substitution (1) $a = \frac{(-)15^2}{2 \times 14}$ evaluation (1) deceleration = 8(.04) (m/s^2)	rearrangement and substitution in either order 225/28 for 2 marks accept – 8(.04) award full marks for the correct answer with no working	**(3)** AO 2 1

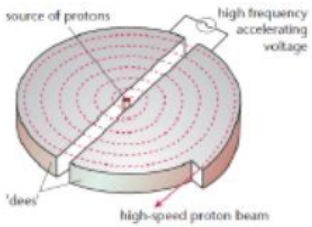
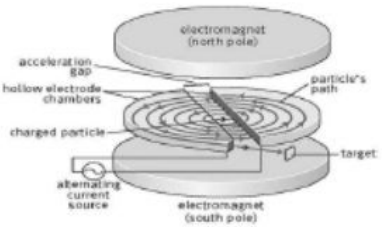
Q6.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	D towards the centre of the circle		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	centripetal (force)	reject centrifugal force accept misspellings where meaning is clear e.g. centripedal	**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(iii)	Any two of the following :- ball slows down (1) ball / it drops (down) / circles at a lower height (1) go in smaller circles (1)	less **kinetic** energy / momentum any lowering / less **potential** energy stops going in circles the ball/it would not make complete circles (not just 'stops')	**(2)**

Question Number	Answer	Acceptable answers	Mark
(a)(iv)	An explanation linking: • the idea that momentum (of the closed system) would stay the same (1) • the idea that kinetic energy would not be conserved (1)	momentum **of the ball** decreases / changes (direction) / passed to wall must specify which momentum; do not credit 'momentum decreases' by itself kinetic energy → heat/sound/wall ignore 'KE decreases / is lost' without qualification allow 'KE is lost because it's not elastic' (i.e. qualified)	**(2)**

Question Number		Indicative Content	Mark
QWC	* **(b)**	A description including some of the following points :- Cyclotron • two D-shaped halves • gap between the Dees • (alternating) voltage across the gap • magnetic field (at right angles to the moving particles) • vacuum enables free movement of particles Particle movement • accelerate • start at the centre • move in a circular path • spiral outwards • exit in a straight line Examples of labelled diagrams which would give Level 3 by themselves (not all labels / details needed)   Level 2 if no labels but Dees AND particle path shown. Level 1 if no labels but either Dees OR spiral of particle shown Ignore uses of cyclotron	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited description of either particle movement OR cyclotron e.g. The particles move in a circle OR Cyclotrons have two Dees OR Cyclotrons are particle accelerators OR there's a vacuum • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• a simple description of particle movement AND cyclotron OR a more detailed description of one e.g. A cyclotron has two D-shaped halves and the particles inside accelerate OR A cyclotron has a magnetic field and a voltage across the gap OR Charged particles increase in speed as they spiral outwards OR vacuum allows free movement of particles • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a description of particle movement AND cyclotron with a detailed description of one of them e.g. the charged particles get faster as they accelerate across the gap in the Dees **OR** the magnetic field (of the cyclotron) causes the particles to move in a circle • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total for Question = 12 marks)

Q7.

Question Number	Answer	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • momentum = mass × velocity • action and reaction are equal and opposite (N 3) • force of R on Q = -force of Q on R • $\frac{\text{change in momentum of Q}}{\text{time}} = \frac{-\text{change in momentum of R}}{\text{time}}$ • time of collision same for both • change in momentum of Q = - change in momentum of R • no overall change in momentum • R accelerates because of force from Q • transfer of momentum between Q and R	**(6)** AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• An explanation that demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• An explanation that demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• An explanation that demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q8.

Question Number	Answer	Additional guidance	Mark
	☒ B centripetal force **The only correct answer is B (correct term for circular motion)** **A** is not correct – incorrect term **C** is not correct – incorrect term **D** is not correct – incorrect term		**(1)**

Q9.

Question Number	Answer	Additional guidance	Mark
	An answer that combines the following points to provide a logical description of the method • mention of a relevant distance and time (1) • use of speed = distance / time (1) • one way of maximising the accuracy (1)	use several lamp posts reference point on car repeat and average in correct context	(3)

Q10.

Question Number	Answer	Additional guidance	Mark
	A description including: measure appropriate distance (1) measure appropriate time (1) use (average) speed = $\frac{\text{distance}}{\text{time}}$ (1)	 e.g. distance along runway from max height to P e.g. start the watch when trolley stops stop the watch when trolley hits spring accept $s = \frac{d}{t}$	(3)

Q11.

	Answer	Acceptable answers	Mark
(ai)	A		(1)
(aii)	A description linking plates move / slip / separate (relative to each other)	plate rubs against each other friction between plates plate boundary	(2)

	(1) sudden (release of energy) (1)	shifts jerk / jolt	
(bi)	substitution (1) 0.65 = 80 / t transposition (1) t = 80 / 0.65 (123 seconds)	transposition and substitution can be in either order . Allow reverse calculations eg speed = 80/120 (1) = 0.67 (about 0.65) (1) or distance = 0.65 × 120 (1) = 78 km (about 80) (1).	**(2)**
(bii)	A description linking any three detection of arrival of P and S waves (1) measurement of difference in arrival times (1) calculation of distance (from epicentre to station) (1) triangulation/using three / several stations (1)	Reward suitable labelled diagram	**(3)**
(b)(iii)	A suggestion including any two of the following Infrasound (1) some animals can hear waves below human frequency range / 20 Hz (1) they could hear P waves arriving before the (stronger) S waves arrive (1)	Some animals have greater audio / tactile sensitivity than humans	**(2)**