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General Certificate of Education (Advanced Level) – Grade 12

UNIT TEST – QUESTION BANK

Physics II – Mechanics

Coverage (competency levels 2.1 – 2.5): Relative motion (parallel paths) · Graphs of motion · Equations of motion (line, vertical, incline) · Projectile motion · Resultant of forces · Moments, couples and parallel forces · Centre of gravity and centre of mass · Inertia and Newton's laws · Momentum, impulse and conservation of momentum · Friction and self-adjusting forces · Applying Newton's laws: connected bodies · Equilibrium · Work, energy and power · Collisions and explosions

01 **E** **II**

Time: 3 hours 30 minutes
(may be taken section by section)

Index No. | | | | | | | | |

Name : .....

School : .....

Instructions

- This book contains **140 questions** in **14 sections**, one section for each sub-topic of the syllabus (competency levels 2.1 – 2.5). Total **214 marks**.
- Questions in each section become progressively more demanding: ● Basic ●● Standard ●●● Exam level ●●●● A/L hardest .
- **Multiple-choice questions** (120): circle the number of the correct or most appropriate answer. Each carries **1 mark**, as in Paper I.
- **Structured questions**: answer in the space provided on this paper. Marks are awarded point by point, **(01)** per marking point, as in the official Paper II marking schemes; the marks for each part are shown at the right.
- Use of calculators is not allowed. Take g = 10 m s^{-2} unless stated otherwise.
- Show all working. A final answer needs the correct unit to earn its mark.

For Examiners' use only

Section	Max	Mk	Section	Max	Mk
A	11		H	16	
B	20		I	14	
C	20		J	15	
D	17		K	12	
E	11		L	22	
F	10		M	21	
G	13		N	12	
				Total	

Total	
MCQ (120)	
Structured (94)	
In numbers (214)	
Percentage	

Code numbers	
Marking examiner	
Checked by 1	
2	
Supervised by	

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SECTION A – Relative motion (parallel paths)

Syllabus 2.1 · Questions A1 – A8 · 11 marks

A1. (• Basic) A passenger in a moving train sees roadside trees moving backwards. This is because **(1 mark)**

(1) the trees are actually moving
(2) the train is accelerating
(3) light travels slowly
(4) the passenger observes from a frame of reference moving relative to the ground
(5) the Earth is rotating

A2. (• Basic) Bodies A and B move along parallel lines with velocities v_A and v_B. The velocity of A relative to B is **(1 mark)**

(1) $v_A - v_B$ (2) $v_B - v_A$ (3) $v_A + v_B$ (4) $v_A v_B$ (5) $(v_A + v_B)/2$

A3. (•• Standard) Two cars move in the same direction on parallel lanes at 25 m s⁻¹ and 20 m s⁻¹. The velocity of the faster car relative to the slower one is **(1 mark)**

(1) 5 m s⁻¹ forward (2) 5 m s⁻¹ backward (3) 45 m s⁻¹ forward
(4) 20 m s⁻¹ forward (5) 25 m s⁻¹ forward

A4. (•• Standard) Car A moves due east at 72 km h⁻¹ and car B moves due west at 54 km h⁻¹ on a parallel road. The velocity of B relative to A is **(1 mark)**

(1) 5 m s⁻¹ due east (2) 5 m s⁻¹ due west (3) 35 m s⁻¹ due east
(4) 126 m s⁻¹ due west (5) 35 m s⁻¹ due west

A5. (••• Exam level) A car moving at 30 m s⁻¹ overtakes a 150 m long train moving at 20 m s⁻¹ in the same direction. Treating the car as a point, the time taken to pass from the rear to the front of the train is **(1 mark)**

(1) 3 s (2) 5 s (3) 7.5 s (4) 15 s (5) 30 s

A6. (••• Exam level) Two trains of lengths 100 m and 150 m move in opposite directions on parallel tracks at 20 m s⁻¹ and 30 m s⁻¹. The time taken for them to completely pass each other is **(1 mark)**

(1) 2 s (2) 3 s (3) 5 s (4) 10 s (5) 25 s

A7. (•••• A/L hardest) The same two trains (100 m at 20 m s⁻¹, 150 m at 30 m s⁻¹) now move in the same direction, the faster one overtaking. The distance travelled over the ground by the faster train while overtaking is **(1 mark)**

(1) 250 m (2) 500 m (3) 625 m (4) 750 m (5) 1250 m

A8. (•••• A/L hardest) A moving walkway 60 m long moves at 1.5 m s⁻¹. A man walks at 1.0 m s⁻¹ relative to the walkway. **(4 marks)**

(a) How long does he take to reach the end if he walks forward? (01)

.....

(b) How long would he take if he walked backward (against the walkway)? (01)

(c) How long if he simply stands? (01)

(d) A jogger runs on the ground beside the walkway at 3.0 m s⁻¹ in the same direction. Find the man's velocity (walking forward) relative to the jogger. (01)

SECTION B – Graphs of motion

Syllabus 2.1 · Questions B1 – B10 · 20 marks

B1. (• Basic) The gradient of a displacement–time graph gives the **(1 mark)**

(1) acceleration (2) force (3) distance
(4) velocity (5) momentum

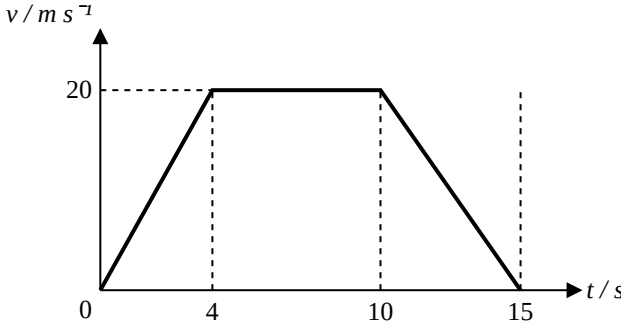
B2. (• Basic) The area under a velocity–time graph gives the **(1 mark)**

(1) displacement (2) velocity (3) acceleration
(4) force (5) jerk

B3. (•• Standard) A horizontal straight line on a velocity–time graph shows that the body **(1 mark)**

(1) has constant velocity (2) is at rest
(3) has constant acceleration (4) is slowing down
(5) is moving in a circle

B4. (•• Standard) The figure shows the velocity–time graph of a car. The distance travelled in 15 s is **(1 mark)**



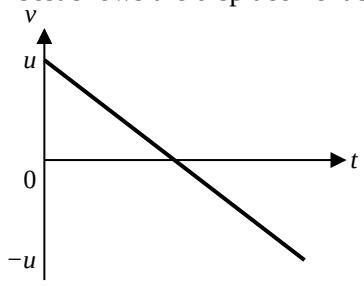
(1) 120 m (2) 170 m (3) 210 m (4) 240 m (5) 300 m

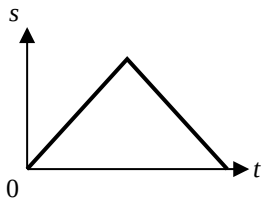
B5. (•• Standard) The speed of a car increases uniformly from 10 m s⁻¹ to 30 m s⁻¹ in 5 s. Its acceleration is **(1 mark)**

(1) 2 m s⁻² (2) 4 m s⁻² (3) 6 m s⁻² (4) 8 m s⁻² (5) 20 m s⁻²

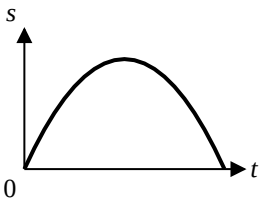
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B6. ●●● Exam level A ball is thrown vertically up and caught at the same level; its v–t graph is shown (upwards positive). Which graph best shows the displacement s against time? **(1 mark)**

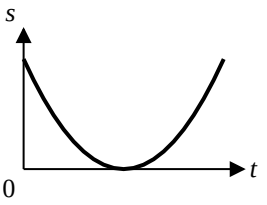




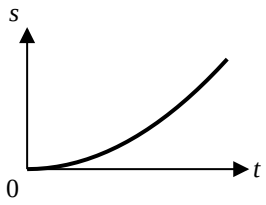
(1)



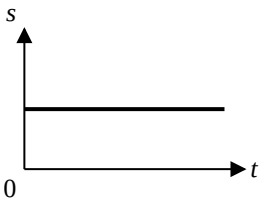
(2)



(3)



(4)



(5)

B7. ●●● Exam level The displacement–time graph of a body is a straight line with a negative gradient. The body **(1 mark)**

(1) is at rest
(2) is accelerating
(3) moves with increasing speed towards the origin
(4) is decelerating
(5) moves with constant velocity in the negative direction

B8. ●●● Exam level A car starts from rest, accelerates uniformly to 20 m s^{-1} in 10 s, moves at constant speed for 20 s and then decelerates uniformly to rest in 8 s. **(6 marks)**

(a) Sketch the velocity–time graph, marking the values. (02)

(b) Find the acceleration and the deceleration. (02)

(c) Find the total distance travelled and the average speed. (02)

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B9. ●●●● A/L hardest The velocity of a body changes uniformly from +10 m s⁻¹ to −10 m s⁻¹ in 4 s. In these 4 s the displacement and the distance travelled are **(1 mark)**

(1) 0 and 0 (2) 0 and 40 m (3) 20 m and 20 m
(4) 40 m and 40 m (5) 0 and 20 m

B10. ●●●● A/L hardest At t = 0 car A starts from rest with acceleration 2 m s⁻². At the same instant car B passes A moving at a constant 20 m s⁻¹ in the same direction. **(6 marks)**

(a) Find when A catches B. (02)

(b) How far have they travelled then, and what is A's speed? (02)

(c) Find the greatest distance between them before A catches B. (02)

SECTION C – Equations of motion (line, vertical, incline)

Syllabus 2.1 · Questions C1 – C13 · 20 marks

C1. ● Basic Which equation of motion does not contain time? **(1 mark)**

(1) $v = u + at$ (2) $s = ut + \frac{1}{2}at^2$ (3) $s = vt$
(4) $s = \frac{1}{2}(u + v)t$ (5) $v^2 = u^2 + 2as$

C2. ● Basic Neglecting air resistance, all bodies falling freely near the Earth have **(1 mark)**

(1) the same acceleration (2) the same velocity (3) the same momentum
(4) the same kinetic energy (5) zero acceleration

C3. ●● Standard A car moving at 20 m s⁻¹ brakes uniformly and stops in 4 s. The braking distance is **(1 mark)**

(1) 10 m (2) 20 m (3) 40 m (4) 60 m (5) 80 m

C4. ●● Standard A stone is dropped from rest. The distance it falls in 3 s is **(1 mark)**

(1) 15 m (2) 30 m (3) 45 m (4) 60 m (5) 90 m

C5. ●● Standard A ball is thrown vertically upwards at 30 m s⁻¹. The maximum height reached is **(1 mark)**

(1) 15 m (2) 30 m (3) 45 m (4) 60 m (5) 90 m

C6. ●●● Exam level A body starts from rest with uniform acceleration and travels 9 m during the 3rd second. Its acceleration is **(1 mark)**

(1) 1.8 m s⁻² (2) 3.0 m s⁻² (3) 3.6 m s⁻² (4) 4.5 m s⁻² (5) 9.0 m s⁻²

C7. ●●● Exam level A ball is thrown vertically up at 20 m s⁻¹. In the first 3 s, the magnitude of its displacement and the distance it travels are **(1 mark)**

(1) 15 m and 15 m (2) 20 m and 25 m (3) 25 m and 15 m
(4) 45 m and 45 m (5) 15 m and 25 m

C8. ●●● Exam level A block is released from rest on a smooth plane inclined at 30°. Its speed after sliding 10 m is **(1 mark)**

(1) 5 m s⁻¹ (2) 7.1 m s⁻¹ (3) 10 m s⁻¹ (4) 14.1 m s⁻¹ (5) 20 m s⁻¹

C9. ●●● Exam level A block is projected up a smooth plane inclined at 30° with a speed of 10 m s⁻¹. The distance it moves up the plane before stopping is **(1 mark)**

(1) 2.5 m (2) 5 m (3) 10 m (4) 15 m (5) 20 m

C10. ●●● Exam level A stone is thrown vertically upwards at 15 m s⁻¹ from the top of a tower 20 m high and falls to the ground beside the tower. **(4 marks)**

(a) Find the time taken to reach the ground. (02)

.....

.....

.....

(b) Find its speed on reaching the ground. (01)

.....

(c) Find the greatest height above the ground. (01)

.....

C11. ●●●● A/L hardest A ball dropped from rest takes time t to fall a height h. The time taken to fall the first h/2 is **(1 mark)**

(1) t/2 (2) t(1 − 1/√2) (3) t/4 (4) t/√2 (5) t√2

C12. ●●●● A/L hardest A balloon rising at 5 m s⁻¹ releases a stone when it is 30 m above the ground. The time for the stone to reach the ground is **(1 mark)**

(1) 2 s (2) √6 s (3) 6 s (4) 3.5 s (5) 3 s

C13. ●●●● A/L hardest A train runs between two stations 2.0 km apart. It accelerates uniformly at 0.5 m s⁻² to a maximum speed of 20 m s⁻¹, runs at that speed, then decelerates uniformly at 1.0 m s⁻² to rest. **(5 marks)**

(a) Sketch the velocity–time graph. (01)

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(b) Find the distances covered while accelerating and decelerating. (02)

(c) Find the total journey time. (02)

SECTION D – Projectile motion

Syllabus 2.1 · Questions D1 – D10 · 17 marks

D1. (• Basic) For a projectile (air resistance neglected), the quantity that stays constant is the **(1 mark)**

(1) vertical component of velocity (2) height
(3) speed (4) horizontal component of velocity
(5) direction of motion

D2. (• Basic) The path of a projectile under gravity, neglecting air resistance, is a **(1 mark)**

(1) parabola (2) circle (3) straight line
(4) ellipse (5) spiral

D3. (•• Standard) A ball rolls off a horizontal table 1.25 m high at 3 m s^{-1}. It lands at a horizontal distance of **(1 mark)**

(1) 0.75 m (2) 1.5 m (3) 2.5 m (4) 3.0 m (5) 3.75 m

D4. (•• Standard) A stone is projected at 40 m s^{-1} at 30° to the horizontal. The maximum height reached is **(1 mark)**

(1) 10 m (2) 20 m (3) 40 m (4) 60 m (5) 80 m

D5. (••• Exam level) For the same stone (40 m s^{-1} at 30°), the horizontal range on level ground is about **(1 mark)**

(1) 40 m (2) 69 m (3) 80 m (4) 139 m (5) 160 m

D6. (••• Exam level) Consider the following statements about a projectile (air resistance negligible). **(1 mark)**

(A) At the highest point its velocity is zero.
(B) Its acceleration is g, vertically downwards, throughout.
(C) The horizontal component of its velocity remains constant.

Of the above statements,

(1) only (A) is true. (2) only (A) and (B) are true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

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D7. ●●● Exam level Two stones are projected with the same speed at 30° and at 60° to the horizontal. **(1 mark)**
Which is correct?

(1) They are in the air for the same time
(2) They have the same maximum height
(3) The 30° stone has the larger range
(4) The 60° stone has the larger range
(5) They have the same range; the 60° stone goes higher

D8. ●●● Exam level A footballer kicks a ball from the ground at 25 m s^{-1} at angle θ to the horizontal **(4 marks)**
($\sin\theta = 0.8$, $\cos\theta = 0.6$) towards a wall 30 m away.

(a) Find the horizontal and vertical components of the initial velocity. (01)

(b) Find the time to reach the wall and the height of the ball there. (02)

(c) Find its velocity on reaching the wall and comment. (01)

D9. ●●●● A/L hardest An aeroplane flies horizontally at constant velocity and releases a food packet. **(1 mark)**
Neglecting air resistance, the pilot sees the packet

(1) fall vertically, always directly below the plane
(2) fall behind the plane along a curve
(3) move ahead of the plane
(4) fall along a straight line inclined backwards
(5) stay at rest

D10. ●●●● A/L hardest A ball is thrown horizontally at 20 m s^{-1} from the top of a cliff 45 m high. **(5 marks)**

(a) Find the time of flight. (01)

(b) Find the horizontal distance from the foot of the cliff. (01)

(c) Find the speed and direction of the ball just before landing. (02)

(d) At what time is the velocity directed at 45° below the horizontal? (01)

SECTION E – Resultant of forces

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Syllabus 2.2 · Questions E1 – E7 · 11 marks

E1. (• Basic) The resultant of a system of forces is **(1 mark)**

(1) the largest of the forces
(2) the sum of their magnitudes
(3) the force needed to balance them
(4) always zero
(5) the single force that produces the same effect as all of them together

E2. (•• Standard) Two forces of 3 N and 4 N act at a point. Which of the following cannot be their resultant? **(1 mark)**

(1) 1 N (2) 3 N (3) 5 N (4) 7 N (5) 8 N

E3. (•• Standard) Two forces, each F, act at 120° to each other. The resultant is **(1 mark)**

(1) F (2) F/2 (3) $\sqrt{2}$ F (4) $\sqrt{3}$ F (5) 2F

E4. (••• Exam level) Forces of 10 N due east, 10 N due north and $10\sqrt{2}$ N due south-west act at a point. The resultant is **(1 mark)**

(1) 20 N east (2) 10 N north-east (3) $10\sqrt{2}$ N north-east
(4) 0 (5) 10 N south-west

E5. (••• Exam level) In the experiment to find the weight W of a body using the parallelogram of forces, the body hangs from a knot tied to two strings that pass over pulleys to weights of 6 N and 8 N. At equilibrium the two strings are at right angles. **(5 marks)**

(a) State the parallelogram law of forces. (02)

.....

.....

.....

(b) Find W. (01)

.....

(c) Find the angle the 8 N string makes with the vertical. (01)

.....

(d) State one precaution in this experiment. (01)

.....

E6. (•••• A/L hardest) Three forces acting at a point keep it in equilibrium. Which set of magnitudes is impossible? **(1 mark)**

(1) 1 N, 2 N, 4 N (2) 2 N, 3 N, 4 N (3) 3 N, 4 N, 5 N
(4) 5 N, 5 N, 5 N (5) 6 N, 8 N, 10 N

E7. (•••• A/L hardest) Three forces of 6 N, 8 N and 10 N keep a particle in equilibrium. The angle between the 6 N and 8 N forces is **(1 mark)**

(1) 37° (2) 53° (3) 60° (4) 90° (5) 120°

SECTION F – Moments, couples and parallel forces

Syllabus 2.2 · Questions F1 – F8 · 10 marks

F1. (• Basic) The moment of a force about a point equals the force multiplied by the **(1 mark)**

(1) distance moved
(2) area of contact
(3) time of action
(4) mass of the body
(5) perpendicular distance from the point to the line of action

F2. (• Basic) The SI unit of the moment of a force is **(1 mark)**

(1) N m (2) N (3) N m^{-1} (4) J s (5) kg m

F3. (•• Standard) A force of 40 N is applied perpendicular to a spanner at 25 cm from the nut. The moment is **(1 mark)**

(1) 1 N m (2) 10 N m (3) 100 N m (4) 160 N m (5) 1000 N m

F4. (•• Standard) Two equal and opposite parallel forces of 10 N are 0.4 m apart. The moment of the couple is **(1 mark)**

(1) 0 (2) 2 N m (3) 4 N m (4) 8 N m (5) 40 N m

F5. (••• Exam level) A force of 20 N acts at the end of a 0.5 m spanner, making 30° with the handle. Its moment about the nut is **(1 mark)**

(1) 2.5 N m (2) 5 N m (3) 8.7 N m (4) 10 N m (5) 20 N m

F6. (••• Exam level) Two parallel forces of 30 N and 20 N act in the same direction, 1.0 m apart. Their resultant is **(1 mark)**

(1) 10 N, 2.0 m from the 20 N force
(2) 50 N, 0.6 m from the 30 N force
(3) 10 N, 0.4 m from the 30 N force
(4) 50 N, midway
(5) 50 N, 0.4 m from the 30 N force

F7. (•••• A/L hardest) Consider the following statements about a couple. **(1 mark)**

(A) The resultant force of a couple is zero.
(B) The moment of a couple is the same about every point.
(C) A couple can be balanced by a single force.

Of the above statements,

(1) only (A) is true.
(2) only (A) and (B) are true.
(3) only (A) and (C) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

F8. (•••• A/L hardest) The steering wheel of a car has a radius of 0.20 m. A driver applies equal and opposite tangential forces of 15 N with each hand at opposite ends of a diameter. **(3 marks)**

(a) Find the moment of the couple. (01)

.....

(b) Explain why the wheel does not move sideways. (01)

(c) Explain why a couple cannot be replaced by a single force. (01)

SECTION G – Centre of gravity and centre of mass

Syllabus 2.2 · Questions G1 – G9 · 13 marks

G1. (• Basic) The centre of gravity of a uniform rod is at its **(1 mark)**

(1) one end (2) point of support only (3) one-third point
(4) one-quarter point (5) midpoint

G2. (• Basic) The centre of gravity of a uniform triangular lamina is at the **(1 mark)**

(1) intersection of the medians
(2) vertex
(3) midpoint of the base
(4) midpoint of the longest side
(5) intersection of the altitudes only in all cases

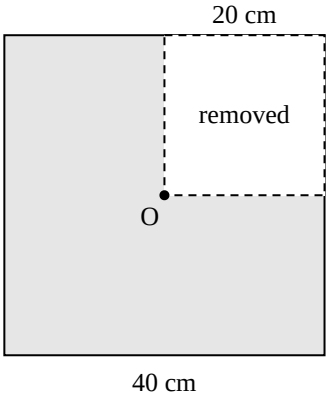
G3. (•• Standard) A uniform rod 60 cm long of mass 0.2 kg has a 0.1 kg mass fixed at end P. The centre of gravity of the system is from P at **(1 mark)**

(1) 10 cm (2) 15 cm (3) 20 cm (4) 25 cm (5) 30 cm

G4. (•• Standard) For which of the following does the centre of gravity lie outside the material of the body? **(1 mark)**

(1) Uniform ring (2) Uniform rod
(3) Uniform solid sphere (4) Uniform rectangular plate
(5) Uniform cylinder

G5. (••• Exam level) A 20 cm square is cut from one corner of a uniform 40 cm square plate. The centre of gravity of the remaining plate is from O (centre of the original plate) about **(1 mark)**



(1) 3.3 cm (2) 4.7 cm (3) 7.1 cm (4) 10 cm (5) 14 cm

G6. (••• Exam level) Masses of 1 kg, 2 kg and 3 kg are fixed to a light rod at the 0 cm, 30 cm and 60 cm marks. **(3 marks)**

(a) Find the position of the centre of gravity. (02)

.....

.....

.....

(b) Where should a single support be placed to keep the rod horizontal? (01)

.....

G7. (••• Exam level) Consider the following statements. **(1 mark)**

(A) A single force through the centre of mass gives only translation.
(B) A single force not through the centre of mass gives translation and rotation.
(C) Internal forces can change the position of the centre of mass.

Of the above statements,

(1) only (A) is true. (2) only (A) and (B) are true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

G8. (•••• A/L hardest) A circular hole of radius R/2 is cut from a uniform disc of radius R; the centre of the hole is R/2 from the centre O of the disc. The centre of gravity of the remainder is from O at **(1 mark)**

(1) R/2 (2) R/6 (3) R/4 (4) R/3 (5) R/8

G9. (•••• A/L hardest) Describe a simple activity to find the centre of gravity of an irregular plane lamina. **(3 marks)**

(03)

.....

.....

.....

.....

SECTION H – Inertia and Newton's laws

Syllabus 2.3 · Questions H1 – H12 · 16 marks

H1. (• Basic) Inertia of a body is its **(1 mark)**

(1) speed
(2) tendency to move
(3) weight
(4) reluctance to change its state of rest or uniform motion
(5) momentum

H2. (• Basic) Newton's first law gives a qualitative definition of **(1 mark)**

(1) force (2) mass (3) momentum
(4) energy (5) acceleration

H3. (• Basic) One newton is the force that gives **(1 mark)**

(1) a mass of 1 kg an acceleration of 1 m s^{-2}
(2) a mass of 1 g an acceleration of 1 m s^{-2}
(3) a mass of 1 kg a velocity of 1 m s^{-1}
(4) a weight of 1 kg
(5) a mass of 1 kg an acceleration of 10 m s^{-2}

H4. (•• Standard) Standing passengers fall forward when a bus suddenly brakes. This is due to **(1 mark)**

(1) friction
(2) air resistance
(3) gravity
(4) the reaction of the floor
(5) inertia

H5. (•• Standard) A resultant force of 12 N acts on a 3 kg body. Its acceleration is **(1 mark)**

(1) 0.25 m s^{-2} (2) 4 m s^{-2} (3) 9 m s^{-2} (4) 15 m s^{-2} (5) 36 m s^{-2}

H6. (••• Exam level) A book rests on a table. According to Newton's third law, the reaction to the Earth's gravitational pull on the book is **(1 mark)**

(1) the normal reaction of the table on the book
(2) the book's push on the table
(3) the table's weight
(4) the book's gravitational pull on the Earth
(5) the friction on the book

H7. (••• Exam level) A person of mass 60 kg stands on a scale in a lift accelerating upward at 2 m s^{-2}. The scale reads **(1 mark)**

(1) 480 N (2) 540 N (3) 600 N (4) 660 N (5) 720 N

H8. (•••• A/L hardest) The same lift is moving downward and slowing down at 2 m s^{-2}. The scale now reads **(1 mark)**

(1) 480 N (2) 540 N (3) 600 N (4) 660 N (5) 720 N

H9. (••• Exam level) Consider the following statements. **(1 mark)**

(A) Mass is a measure of translational inertia.
(B) The net force on a body moving at constant velocity is zero.
(C) Inertial mass and gravitational mass of a body are found to be equal.

Of the above statements,

(1) only (A) is true.
(2) only (A) and (B) are true.
(3) only (A) and (C) are true.
(4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

H10. (••• Exam level) Newton's first law is valid in a frame of reference that is **(1 mark)**

(1) accelerating
(2) rotating
(3) in free fall only
(4) at rest or moving with constant velocity relative to an inertial frame
(5) attached to a turning car

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H11. ●●●● A/L hardest A 50 kg person stands on a weighing scale in a lift. Find the scale reading when the lift is **(5 marks)**

(a) at rest (01)

(b) accelerating upward at 2 m s⁻² (01)

(c) moving upward at a constant 3 m s⁻¹ (01)

(d) falling freely (cable broken). Explain the result. (01)

(e) Draw a free-body diagram for the person in (b). (01)

H12. ●●●● A/L hardest A horse pulls a cart. The cart pulls back on the horse with an equal force. The cart moves forward because **(1 mark)**

(1) the forces act on different bodies; the cart moves when the horse's pull exceeds the friction on the cart
(2) action and reaction cancel
(3) the horse's pull is larger than the cart's pull
(4) the cart has no inertia
(5) Newton's third law does not apply to animals

SECTION I – Momentum, impulse and conservation of momentum

Syllabus 2.3 · Questions I1 – I11 · 14 marks

I1. ● Basic The SI unit of momentum is **(1 mark)**

(1) kg m s⁻² (2) J s (3) N m (4) kg m s⁻¹ (5) kg m² s⁻¹

I2. ● Basic Impulse is equal to **(1 mark)**

(1) force × distance (2) rate of change of momentum
(3) mass × acceleration (4) change of momentum
(5) kinetic energy

I3. ●● Standard The momentum of a 0.2 kg ball moving at 10 m s⁻¹ is **(1 mark)**

(1) 0.02 N s (2) 2 N s (3) 10 N s (4) 20 N s (5) 50 N s

I4. ●● Standard A constant force of 5 N acts for 3 s on a 2 kg body initially at rest. Its final speed is **(1 mark)**

(1) 2.5 m s⁻¹ (2) 3.3 m s⁻¹ (3) 7.5 m s⁻¹ (4) 15 m s⁻¹ (5) 30 m s⁻¹

I5. ●●● Exam level A 0.2 kg ball hits a wall at 10 m s⁻¹ and rebounds at 8 m s⁻¹. Contact time 0.05 s. The average force on the ball is **(1 mark)**

(1) 3.6 N (2) 7.2 N (3) 8 N (4) 40 N (5) 72 N

I6. ●●● Exam level A cricketer moves his hands backwards while catching a fast ball because this **(1 mark)**

(1) reduces the change of momentum
(2) increases the time of contact and so reduces the force
(3) increases the impulse
(4) reduces the mass of the ball
(5) stops the ball faster

I7. ●●● Exam level A 4.0 kg rifle fires a 20 g bullet at 400 m s^{-1}. The recoil speed of the rifle is **(1 mark)**

(1) 0.5 m s^{-1} (2) 1.0 m s^{-1} (3) 2.0 m s^{-1} (4) 4.0 m s^{-1} (5) 8.0 m s^{-1}

I8. ●●● Exam level A 2 kg trolley moving east at 6 m s^{-1} collides with a 3 kg trolley moving west at 2 m s^{-1}. They stick together. Their common velocity is **(1 mark)**

(1) 0.8 m s^{-1} east (2) 2.4 m s^{-1} east (3) 1.2 m s^{-1} west
(4) 3.6 m s^{-1} east (5) 1.2 m s^{-1} east

I9. ●●●● A/L hardest A 3 kg object at rest explodes into 1 kg and 2 kg pieces. The 1 kg piece moves at 20 m s^{-1}. The 2 kg piece moves at **(1 mark)**

(1) 10 m s^{-1} in the opposite direction (2) 10 m s^{-1} in the same direction
(3) 20 m s^{-1} opposite (4) 40 m s^{-1} opposite
(5) 5 m s^{-1} opposite

I10. ●●●● A/L hardest A force on a 0.5 kg ball, initially at rest, rises uniformly from 0 to 200 N and falls back to 0 in a total time of 0.04 s. The speed of the ball afterwards is **(1 mark)**

(1) 2 m s^{-1} (2) 4 m s^{-1} (3) 8 m s^{-1} (4) 16 m s^{-1} (5) 400 m s^{-1}

I11. ●●●● A/L hardest A 0.15 kg cricket ball moving horizontally at 20 m s^{-1} is hit straight back at 30 m s^{-1}. The bat is in contact for 0.010 s. **(4 marks)**

(a) Find the impulse on the ball. (01)

(b) Find the average force from the bat. (01)

(c) Name the law that gives the force of the ball on the bat, and state its size. (01)

(d) Explain why a person jumping down from a wall bends the knees on landing. (01)

SECTION J – Friction and self-adjusting forces

Syllabus 2.3 · Questions J1 – J10 · 15 marks

J1. (• Basic) Frictional force always acts **(1 mark)**

(1) in the direction of motion
(2) perpendicular to the surfaces
(3) vertically upward
(4) to oppose relative motion (or the tendency to move) between surfaces
(5) only on moving bodies

J2. (• Basic) Which of the following is not a self-adjusting force? **(1 mark)**

(1) Tension in a string (2) Static friction (3) Normal reaction
(4) Weight of a body (5) Thrust in a strut

J3. (•• Standard) A 5 kg box rests on a floor; $\mu_s = 0.40$. The limiting frictional force is **(1 mark)**

(1) 2 N (2) 12.5 N (3) 20 N (4) 50 N (5) 200 N

J4. (•• Standard) A horizontal force of 15 N is applied to the same box ($\mu_s = 0.40$, $\mu_k = 0.25$). The frictional force on the box is **(1 mark)**

(1) 0 (2) 12.5 N (3) 15 N (4) 20 N (5) 35 N

J5. (••• Exam level) The force on the same box is increased to 25 N. The acceleration of the box is **(1 mark)**

(1) 0 (2) 1.0 m s^{-2} (3) 2.5 m s^{-2} (4) 3.0 m s^{-2} (5) 5.0 m s^{-2}

J6. (••• Exam level) A block on a plank just starts to slide when the plank is raised to 37° ($\tan 37° = 0.75$). The coefficient of static friction is **(1 mark)**

(1) 0.37 (2) 0.60 (3) 0.75 (4) 0.80 (5) 1.33

J7. (••• Exam level) Consider the following statements about friction. **(1 mark)**

(A) The coefficient of kinetic friction is usually less than that of static friction.
(B) Limiting friction depends on the area of contact.
(C) Limiting friction is proportional to the normal reaction.

Of the above statements,

(1) only (A) is true. (2) only (A) and (B) are true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

J8. (•••• A/L hardest) A 2 kg block is pressed against a vertical wall by a horizontal force of 50 N. $\mu_s = 0.5$. The frictional force on the block is **(1 mark)**

(1) 0 (2) 10 N (3) 20 N (4) 25 N (5) 50 N

J9. (•••• A/L hardest) A box lies on the floor of a truck; $\mu_s = 0.3$. The greatest acceleration of the truck without the box sliding is **(1 mark)**

(1) 0.3 m s^{-2} (2) 1 m s^{-2} (3) 3 m s^{-2} (4) 10 m s^{-2} (5) 30 m s^{-2}

J10. ●●●● A/L hardest A 2.0 kg block on a plank just begins to slide when the plank is at 37° (sin37° = 0.6, cos37° = 0.8). **(6 marks)**

(a) Draw the free-body diagram of the block just before it slides. (01)

(b) Show that $\mu_s = \tan\theta$ and find it. (02)

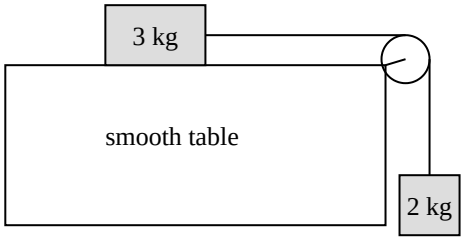
(c) While sliding at 37°, a = 1.6 m s⁻². Find μ_k. (02)

(d) Find the friction on the block at rest when the plank is at 20° (sin20° = 0.34). (01)

SECTION K – Applying Newton's laws: connected bodies

Syllabus 2.3 · Questions K1 – K7 · 12 marks

K1. ●● Standard A 3 kg block on a smooth table is joined over a smooth pulley to a hanging 2 kg block. The tension in the string is **(1 mark)**



(1) 8 N (2) 12 N (3) 20 N (4) 24 N (5) 30 N

K2. ●●● Exam level The table in the previous question is now rough with $\mu_k = 0.2$. The tension is **(1 mark)**

(1) 12.0 N (2) 14.4 N (3) 16.0 N (4) 17.2 N (5) 20.0 N

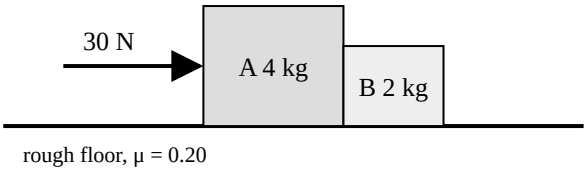
K3. ●●● Exam level Masses of 3 kg and 2 kg hang on either side of a smooth fixed pulley. The tension in the string is **(1 mark)**

(1) 20 N (2) 24 N (3) 25 N (4) 30 N (5) 50 N

K4. ●●● Exam level Blocks A (4 kg) and B (2 kg) in contact on a smooth floor are pushed by 30 N applied to A. The force of A on B is **(1 mark)**

(1) 5 N (2) 10 N (3) 15 N (4) 20 N (5) 30 N

K5. ●●●● A/L hardest Blocks A (4 kg) and B (2 kg) are in contact on a rough floor ($\mu_k = 0.20$). A horizontal force of 30 N pushes A. **(6 marks)**



(a) Draw separate free-body diagrams for A and B. (02)

(b) Find the acceleration. (02)

(c) Find the force of A on B and state the force of B on A. (02)

K6. ●●●● A/L hardest A 2 kg block on a smooth plane inclined at 30° is connected by a string over a pulley at the top of the plane to a hanging 3 kg mass. The acceleration of the system is **(1 mark)**

(1) 2 m s⁻² (2) 4 m s⁻² (3) 6 m s⁻² (4) 8 m s⁻² (5) 10 m s⁻²

K7. ●●●● A/L hardest An engine pulls three identical wagons, each 10 000 kg, on a frictionless track with a force of 60 kN applied to the first wagon. The tension in the coupling between the first and second wagons is **(1 mark)**

(1) 10 kN (2) 20 kN (3) 30 kN (4) 40 kN (5) 60 kN

SECTION L – Equilibrium

Syllabus 2.4 · Questions L1 – L11 · 22 marks

L1. ● Basic A rigid body is in equilibrium under coplanar forces when **(1 mark)**

(1) only the resultant force is zero
(2) only the total moment is zero
(3) it moves with constant acceleration
(4) it is at rest
(5) the resultant force is zero and the total moment about any point is zero

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L2. (• Basic) An object that, when slightly tilted, returns to its original position is in **(1 mark)**

(1) dynamic equilibrium only (2) unstable equilibrium (3) neutral equilibrium
(4) stable equilibrium (5) no equilibrium

L3. (•• Standard) A uniform metre rule balances at the 40 cm mark when a 30 g mass hangs at the 10 cm mark. The mass of the rule is **(1 mark)**

(1) 30 g (2) 45 g (3) 60 g (4) 90 g (5) 120 g

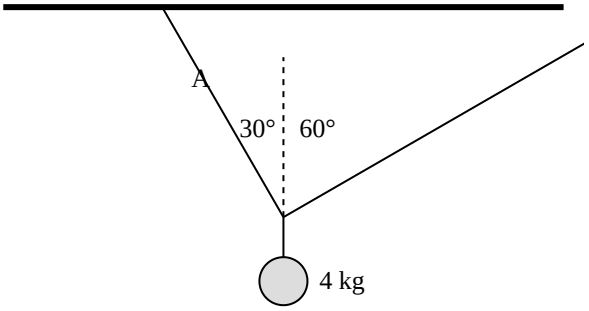
L4. (•• Standard) A cone lying on its curved side is in **(1 mark)**

(1) neutral equilibrium (2) unstable equilibrium (3) stable equilibrium
(4) no equilibrium (5) rotational motion

L5. (••• Exam level) If three non-parallel coplanar forces keep a body in equilibrium, their lines of action must **(1 mark)**

(1) pass through one point (2) be parallel (3) be perpendicular
(4) form a square (5) be equal in magnitude

L6. (••• Exam level) A 4 kg lamp hangs from two strings making 30° and 60° with the vertical. The tension in the string at 60° to the vertical is **(1 mark)**

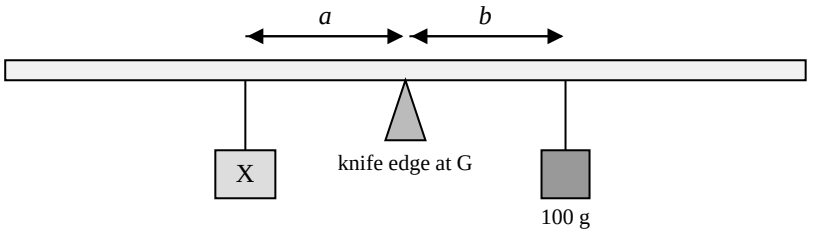


(1) 20 N (2) 23 N (3) 34.6 N (4) 40 N (5) 46 N

L7. (••• Exam level) A uniform 4 m beam of weight 200 N rests on supports at its ends A and B. A load of 400 N is placed 1 m from A. The reaction at B is **(1 mark)**

(1) 100 N (2) 200 N (3) 300 N (4) 400 N (5) 600 N

L8. (••• Exam level) To find the weight W of object X, a uniform metre rule is balanced on a knife edge at its centre of gravity G. X hangs at distance a on one side and a 100 g mass at distance b on the other. Readings (cm): a = 10.0, 15.0, 20.0, 25.0, 30.0; b = 16.1, 23.9, 32.0, 40.1, 47.9. **(5 marks)**



(a) Why is the knife edge kept at G? (01)

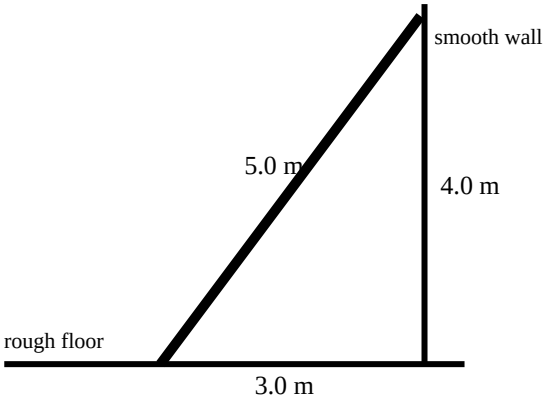
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(b) State the principle of moments. (01)

(c) Write the relation between a and b. (01)

(d) Find the gradient of b against a and hence W. (02)

L9. ●●●● A/L hardest A uniform ladder 5.0 m long, weight 200 N, rests against a smooth wall with its foot 3.0 m from the wall on a rough floor. **(8 marks)**



(a) Mark the forces on the ladder. (01)

(b) Find the reaction S at the wall. (02)

(c) Find R, F and the least coefficient of friction. (02)

(d) $\mu = 0.50$. How far up the ladder can a 600 N man climb before it slips? (03)

L10. ●●●● A/L hardest A uniform horizontal rod 1 m long, weight 20 N, is hinged to a wall at one end and held by a string attached to the other end making 30° with the rod. The tension is **(1 mark)**

(1) 10 N (2) 17.3 N (3) 20 N (4) 34.6 N (5) 40 N

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L11. ●●●● A/L hardest Consider the following statements about stability. **(1 mark)**

(A) Lowering the centre of gravity of a body increases its stability.

(B) Widening the base of a body increases its stability.

(C) A body topples when the vertical line through its centre of gravity falls outside its base.

Of the above statements,

(1) only (A) is true. (2) only (A) and (B) are true.

(3) only (A) and (C) are true. (4) only (B) and (C) are true.

(5) all (A), (B) and (C) are true.

SECTION M – Work, energy and power

Syllabus 2.5 · Questions M1 – M16 · 21 marks

M1. ● Basic The work done by a force acting perpendicular to the displacement is **(1 mark)**

(1) zero (2) maximum (3) negative

(4) equal to the force (5) infinite

M2. ● Basic One watt is equal to **(1 mark)**

(1) 1 J s (2) 1 kg m s^{-2} (3) 1 N s (4) 1 N m s (5) 1 J s^{-1}

M3. ●● Standard A force of 50 N pulling at 60° to the horizontal moves a box 4 m horizontally. The work done is **(1 mark)**

(1) 50 J (2) 100 J (3) 173 J (4) 200 J (5) 400 J

M4. ●● Standard The kinetic energy of a 2 kg body moving at 3 m s^{-1} is **(1 mark)**

(1) 3 J (2) 6 J (3) 9 J (4) 12 J (5) 18 J

M5. ●● Standard The gain in potential energy when a 5 kg mass is raised 2 m is **(1 mark)**

(1) 10 J (2) 25 J (3) 50 J (4) 100 J (5) 200 J

M6. ●● Standard A spring of force constant 200 N m^{-1} is compressed 0.10 m. The elastic potential energy stored is **(1 mark)**

(1) 0.5 J (2) 1 J (3) 2 J (4) 10 J (5) 20 J

M7. ●●● Exam level A ball is dropped from 20 m. Neglecting air resistance, its speed on reaching the ground is **(1 mark)**

(1) 10 m s^{-1} (2) 14 m s^{-1} (3) 20 m s^{-1} (4) 40 m s^{-1} (5) 200 m s^{-1}

M8. ●●● Exam level That spring (200 N m^{-1}, compressed 0.10 m) projects a 0.05 kg ball along a smooth surface. The ball's speed is about **(1 mark)**

(1) 2.0 m s^{-1} (2) 4.5 m s^{-1} (3) 6.3 m s^{-1} (4) 20 m s^{-1} (5) 40 m s^{-1}

M9. ●●● Exam level A crane lifts 500 kg through 12 m in 20 s at constant speed with 60 % efficiency. Its input power is **(1 mark)**

(1) 1.8 kW (2) 3.0 kW (3) 3.6 kW (4) 5.0 kW (5) 6.0 kW

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M10. (●●● Exam level) A car moves at a constant 20 m s⁻¹ against a total resistance of 500 N. The power of the engine is **(1 mark)**

(1) 1 kW (2) 10 kW (3) 20 kW (4) 25 W (5) 500 W

M11. (●●● Exam level) A 1000 kg car moving at 20 m s⁻¹ is brought to rest in 40 m. The average braking force is **(1 mark)**

(1) 10 000 N (2) 20 000 N (3) 500 N (4) 2500 N (5) 5000 N

M12. (●●●● A/L hardest) Two bodies of masses 1 kg and 4 kg have equal momenta. The ratio of their kinetic energies (1 kg : 4 kg) is **(1 mark)**

(1) 4 : 1 (2) 1 : 2 (3) 1 : 1 (4) 2 : 1 (5) 1 : 4

M13. (●●●● A/L hardest) A 1000 kg car's engine has a constant power of 30 kW and its maximum speed on a level road is 30 m s⁻¹. If the resistance stays the same, the car's acceleration when its speed is 20 m s⁻¹ is **(1 mark)**

(1) 0.25 m s⁻² (2) 0.5 m s⁻² (3) 1.0 m s⁻² (4) 1.5 m s⁻² (5) 2.0 m s⁻²

M14. (●●●● A/L hardest) A pendulum bob is released from rest 0.45 m above its lowest point. Its speed at the lowest point is **(1 mark)**

(1) 0.9 m s⁻¹ (2) 1.5 m s⁻¹ (3) 3.0 m s⁻¹ (4) 4.5 m s⁻¹ (5) 9.0 m s⁻¹

M15. (●●●● A/L hardest) A 50 kg child starts from rest at the top of a slide of vertical height 5.0 m and length 10 m and reaches the bottom at 8.0 m s⁻¹. **(4 marks)**

(a) Find the loss of potential energy and the gain of kinetic energy. (02)

(b) Find the work done against friction and the average frictional force. (02)

M16. (●●●● A/L hardest) An electric pump lifts 600 kg of water per minute through 15 m and delivers it at 2.0 m s⁻¹. The input power is 2.0 kW. **(3 marks)**

(a) Find the useful output power. (02)

(b) Find the efficiency. (01)

SECTION N – Collisions and explosions

Syllabus 2.5 · Questions N1 – N8 · 12 marks

N1. (• Basic) In every collision between two bodies (no external force) the quantity conserved is the total **(1 mark)**

(1) momentum (2) kinetic energy (3) speed
(4) potential energy (5) force

N2. (• Basic) A collision in which the total kinetic energy is conserved is called **(1 mark)**

(1) inelastic (2) perfectly inelastic (3) explosive
(4) elastic (5) impulsive

N3. (•• Standard) A 2 kg trolley at 6 m s^{-1} east collides with a 3 kg trolley at 2 m s^{-1} west; they stick. The loss of kinetic energy is **(1 mark)**

(1) 3.6 J (2) 19.2 J (3) 38.4 J (4) 42 J (5) 45.6 J

N4. (••• Exam level) Consider the following statements. **(1 mark)**

(A) In an elastic collision kinetic energy is conserved.
(B) In an inelastic collision momentum is not conserved.
(C) The net work on a body equals the change in its kinetic energy.

Of the above statements,

(1) only (A) is true. (2) only (A) and (B) are true.
(3) only (A) and (C) are true. (4) only (B) and (C) are true.
(5) all (A), (B) and (C) are true.

N5. (••• Exam level) A 3 kg object at rest explodes into 1 kg and 2 kg pieces; the 1 kg piece moves at 20 m s^{-1}. The kinetic energy released is **(1 mark)**

(1) 100 J (2) 200 J (3) 300 J (4) 400 J (5) 600 J

N6. (•••• A/L hardest) A ball collides head-on and elastically with an identical ball at rest. After the collision **(1 mark)**

(1) both move together at half speed
(2) the second moves at twice the speed
(3) the first rebounds with the same speed
(4) both stop
(5) the first ball stops and the second moves with the first ball's original velocity

N7. (•••• A/L hardest) A 1 kg ball at 6 m s^{-1} collides head-on elastically with a 2 kg ball at rest. The speed of the 2 kg ball afterwards is **(1 mark)**

(1) 2 m s^{-1} (2) 3 m s^{-1} (3) 4 m s^{-1} (4) 6 m s^{-1} (5) 12 m s^{-1}

N8. (•••• A/L hardest) A 20 g bullet at 300 m s^{-1} embeds itself in a 1.98 kg block hanging at rest from long strings. **(5 marks)**

(a) Find the velocity just after impact. (01)

(b) Find the height the block rises. (01)

(c) Find the kinetic energy lost and classify the collision. (02)

(d) Why can energy conservation not be used for the impact itself? (01)

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SCORE CARD

Fill in after marking with the marking scheme

Section	Sub-topic	Max	My marks	%	Redo?
A	Relative motion (parallel paths)	11			
B	Graphs of motion	20			
C	Equations of motion (line, vertical, incline)	20			
D	Projectile motion	17			
E	Resultant of forces	11			
F	Moments, couples and parallel forces	10			
G	Centre of gravity and centre of mass	13			
H	Inertia and Newton's laws	16			
I	Momentum, impulse and conservation of momentum	14			
J	Friction and self-adjusting forces	15			
K	Applying Newton's laws: connected bodies	12			
L	Equilibrium	22			
M	Work, energy and power	21			
N	Collisions and explosions	12			
Total		**214**			

Self-check bands (a guide, not official A/L grade boundaries): 75 % and above – exam ready · 65–74 % – polish the ●●●● questions · 50–64 % – redo the ●●● and ●●●● questions · below 50 % – read the revision notes for that section and redo it.

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