Newton's Laws of Motion

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Dynamics
Sub Topic	Newton's Laws of Motion
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **80 minutes**

Score: **/66**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** $4.5 \times 50 - 2.8 \times M$ (= ...) C1

(...) = $-1.8 \times 50 + 1.4 \times M$ C1

(M =) 75 g A1 [3]

(b) <u>total</u> initial kinetic energy/KE not equal to the total final kinetic energy/KE

or <u>relative</u> speed of approach is not equal to relative speed of separation

so not elastic or is inelastic B1 [1]

(c) force on X is equal and opposite to force on Y (Newton III) M1

force equals/is proportional to rate of change of momentum (Newton II) M1

time of collision same for both balls hence change in momentum is the same A1 [3]

2 **(a (i)** acceleration = $(v - u) / t$ or $(12 - 0.5) / 4$ C1

= $(12 - 0.5) / 4$ = 2.9 (2.875) (= approximately 3 m s^{-2}) M1 [2]

(ii) $x = (u + v)t / 2$

= $[(12 + 0.5) \times 4] / 2$ C1

= 25 m A [2]

(iii) line with increasing gradient M1

non-zero gradient at origin A1 [2]

(b) (i) weight down slope = $2 \times 9.81 \times \sin 25°$ = 8.29 / 8.3 M1 [1]

(ii) ($F = ma$) $8.3 - F_R = 2 \times 2.9$ C1

F_R = 2.5 (2.3 if 3 used for a) N A1 [2]

3 **(a) (i)** *either* rate of change of displacement
or (change in) displacement / time (taken) B1 [1]

(ii) speed has magnitude only B1
velocity has magnitude and direction B1 [2]

(b) (i) idea of area under graph / use of $s = \frac{(u+v)}{2} \times t$ C1

$s = \frac{(18+32)}{2} \times 2.5$ C1

$= 62.5$ m A1 [3]

(ii) $a = (18 - 32) / 2.5$ (= –5.6) C1
$F = ma$ C1
$F = 1500 \times (-) 5.6 = (-) 8400$ N A1 [3]

(c) arrow labelled A and arrow labelled F both to the left B1 [1]

4 **(a** units for D identified as kg m s^{-2} M1
all other units shown: units for A: m^2 units for v^2: m^2s^{-2} units for ρ: kg m^{-3}

$C = \frac{\text{kg m s}^{-2}}{\text{kg m}^{-3}\ \text{m}^2\ \text{m}^2\text{s}^{-2}}$ with cancelling / simplification to give C no units A1 [2]

(b) (i) straight line from (0,0) to (1,9.8) ± half a square B1 [1]

(ii) $\frac{1}{2} mv^2 = mgh$ or using $v^2 = 2as$ C1
$v = (2 \times 9.81 \times 1000)^{1/2} = 140\ \text{m s}^{-1}$ A1 [2]

(c) (i) weight = drag (D) (+ upthrust) B1 [1]
Allow mg or W for weight and D or expression for D for drag

(ii) **1.** $mg = 1.4 \times 10^{-5} \times 9.81$ C1

$1.4 \times 10^{-5} \times 9.81 = 0.5 \times 0.6 \times 1.2 \times 7.1 \times 10^{-6} \times v^2$ M1

$v = 7.33\ \text{m s}^{-1}$ A0 [2]

2. line from (0,0) correct curvature to a horizontal line at velocity of $7\ \text{m s}^{-1}$ M1
line reaches $7\ \text{m s}^{-1}$ between 1.5 s and 3.5 s A [2]

5 **(a)** 2.4 s …….. A1 [1]

(b) in **(b)** and **(c)**, allow answers as (+) or (–)
recognises distance travelled as area under graph line …….. C1
height = (½ × 2.4 × 9.0) – (½ × 1.6 × 6.0) …….. C1
= 6.0 m (*allow 6 m*) …… A1 [3]
(*answer 15.6 scores 2 marks*
answer 10.8 or 4.8 scores 1 mark)

alternative solution: $s = ut - \frac{1}{2}at^2$
$= (9 \times 4) - \frac{1}{2} \times (9 / 2.4) \times 4^2$
= 6.0 m
(*answer 66 scores 2 marks*
answer 36 or 30 scores 1 mark)

(c) **(i)** change in momentum = 0.78 (9.0 + 4.2) (*allow 4.2 ± 0.2*) …… C1
= 10.3 N s (allow 10 N s) …… A1 [2]

(ii) force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$ …… C1
= 10.3 / 3.5 / 0.08
= 2.9 N …… A1 [2]

(d) **(** 2.9 N …….. A1 [1]

(ii) g = weight / mass …… C1
= 2.9 / 0.78
= 3.7 m s^{-2} …….. A1 [2]

6 **(a** moment: force × <u>perpendicular</u> distance M1
of force from pivot / axis / point A1
couple: (magnitude of) one force × <u>perpendicular</u> distance M1
between the two forces A1 [4]
(*penalise the 'perpendicular' omission once only*)

(b) **(i)** $W \times 4.8 = (12 \times 84) + (2.5 \times 72)$ C1
W = 250 N (248 N) A1 [2]

(ii) *either* friction <u>at the pivot</u> *or* small movement of weights B1 [1]

7 **(a) (i)** $v^2 = 2as$
$1.2^2 = 2 \times a \times 1.9$ M1
$a = 0.38\ \text{m s}^{-2}$ A1 [2]

(ii) $F = ma$
$= 42 \times 0.38$ M1
$= 16\ \text{N}$ A0 [1]

(b) *power* $= Fv$ C1
$= 16 \times 1.2$
$= 19\ \text{W}$ A1 [2]

(c) (i) component $= 42 \times 9.8 \times \sin 2.8$ C1
$= 20.1\ \text{N}$ A1 [2]

(ii) accelerating force $= 20.1 - 16 = 4.1\ \text{N}$ C1
acceleration of trolley $= 4.1 / 42 = 0.098\ \text{m s}^{-2}$ C1
$s = \frac{1}{2}at^2$
$3.5 = \frac{1}{2} \times 0.098 \times t^2$ C1
$t = 8.5\ \text{s}$ A1 [4]

(d) *either* allows plenty of time to stop runaway trolley
or speed of trolley increases gradually
or trolley will travel faster B1 [1]
(answer must be unambiguous when read in conjunction with question)