1) B
2) A
3) C
4) D
5) A
6) B
7) D
8) A
9) B
10) A
11) A
12) D
13)

(i)	momentum before cutting thread = momentum after	C1	
	0 = 2400 × V – 800 × v	M1	
	v / V = 3.0	A0	[2]

14)

(a)	$v^2 = 2gh$		
	$v^2 = 2 \times 9.8 \times 1.6$	C1	
	$v = 5.6\ \text{m s}^{-1}$	A1	[2]
(b) (i)	working leading to idea that $h = 0.90 \times 1.6$	C1	
	$h = 1.44\ \text{m}$	A1	
(ii)	$mgh = ½mv^2$		
	$v^2 = 2 \times 9.8 \times 1.44$	C1	
	$v = 5.3\ \text{m s}^{-1}$	A1	[4]
(c)	$\Delta p = m(v - u)$ OR $p = mv$	C1	
	$m = 0.073\ \text{kg}$		
	$\Delta p = 0.073 \times (5.6 + 5.3)$	C1	
	$= 0.80\ \text{N s}$	A1	[3]
(d)	steel plate (and Earth)	B1	
	must gain momentum of 0.80 N s	M1	
	in downward direction	A1	[3]
	(idea of Earth/plate and ball as the system scores 1/3)		

15)

(a)	$v^2 = u^2 + 2as$ OR use of triangle etc	C1	
	$4.0^2 = 2 \times 9.8 \times s$ OR $s = ½ \times 4.0 \times 0.4$		
	$s = 0.82$ m OR 0.80 m	A1	[2]
(b)	$\Delta p = m(v - u)$ OR $p = mv$	C1	
	speeds are 4.2 m s^{-1} and 3.6 m s^{-1}	C1	
	$\Delta p = 0.045\ (4.2 + 3.6)$ (2/4 only if speeds not added)	C1	
	$= 0.35$ N s	A1	[4]
	(1 mark only if only one speed used)		
(c)	any time between 0.14 s and 0.17 s	C1	
	force $= \Delta p / \Delta t = 0.35 / 0.14$ (allow e.c.f.)		
	$= 2.5$ N	A1	[2]

16)

(a)	**(i)**	(p =) mv	B1	
	(ii)	$E_k = \frac{1}{2}mv^2$	B1	
		algebra leading to	M1	
		$E_k = p^2/2m$	A0	**[3]**
(b)	**(i)**	$\Delta p = 0.035\ (4.5 + 3.5)$ OR $a = (4.5 + 3.5)/0.14$	C1	
		$= 0.28$ N s $= 57.1$ m s^{-2}		
		force= $\Delta p/\Delta t$ (= 0.28/0.14) OR F = ma (= 0.035 x 575.1) (allow e.c.f.)	C1	
		= 2.0 N	A1	
		Note: candidate may add mg = 0.34 N to this answer, deduct 1 mark		
		upwards	B1	**[4]**
	(ii)	loss = $\frac{1}{2} \times 0.035\ (4.5^2 - 3.5^2)$	C1	
		= 0.14 J	A1	**[2]**
		(No credit for $0.28^2/(2 \times 0.035) = 1.12$ J)		
(c)		e.g. plate (and Earth) gain momentum		
		i.e. discusses a 'system'	B1	
		equal and opposite to the change for the ball		
		i.e. discusses force/momentum	M1	
		so momentum is conserved		
		i.e. discusses consequence	A1	**[3]**
		Total		**[12]**

17)

(a) constant gradient/straight line	**B1**	**[1]**
(b) (i) 1.2 s	**A1**	
(ii) 4.4 s	**A1**	**[2]**
(c) *either* use of area under line *or* h = average speed x time	**C1**	
$h = ½ \times (4.4 – 1.2) \times 32$	**C1**	
$= 51.2$ m	**A1**	**[3]**

(allow 2/3 marks for determination of h = 44 m or h =58.4 m
allow 1/3 marks for answer 7.2 m)

(d) $\Delta p = m\Delta v$ OR $p = mv$	**C1**	
$= 0.25 \times (28 + 12)$	**C1**	
= 10 N s	**A1**	**[3]**

(answer 4 N s scores 2/3 marks)

(e) (i) total/sum momentum before = total/sum momentum after		**B1**	
in any closed system		**B1**	**[2]**
(ii) *either* the system is the ball and Earth		**B1**	
momentum of Earth changes by same amount		**B1**	
but in the opposite direction		**B1**	
or Ball is not an isolated system/there is a force on the ball	(B1)		
Gravitational force acts on the ball	(B1)		
causes change in momentum/law does not apply here	(B1)		**[3]**

(if explains in terms of air resistance, allow first mark only)

18)

(a)	ball moving in opposite direction (after collision)	B1	[1]
(b) (i)	change in momentum = 1.2 (4.0 + 0.8)	C2	
	(*correct values, 1 mark; correct sign {values added}, 1 mark*)		
	= 5.76 N s …(*allow 5.8*)	A1	[3]
(ii)	force = $\Delta p / \Delta t$ or $m\Delta v / \Delta t$	C1	
	= 5.76 / 0.08 or 1.2 × 4.8 / 0.08	C1	
	= 72 N	A1	[3]
(c)	5.76 = 3.6 × V	C1	
	V = 1.6 m s^{-1}	A1	[2]
(d)	*either* speed of approach = 4.0 m s^{-1} and		
	speed of separation = 2.4 m s^{-1}	M1	
	not equal and so inelastic	A1	
	or kinetic energy before = 9.6 J and		
	kinetic energy after collision = 4.99 J	M1	
	kinetic energy after is less / not conserved so inelastic	A1	[2]

19)

(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: $s = ut - ½at^2$
$= (9 × 4) - ½ × (9 / 2.4) × 4^2$
$= 6.0$ 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) **(i)** 2.9 N .... A1 [1]

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