1. Motion, forces and energy

1.6 Momentum

Paper 3 and 4

Answer Key

Paper 4

Q1.

Question	Answer	Marks
(a)	(momentum is) mass × velocity	**B1**
(b)(i)	1.9 N s **OR** 1.9 kg m / s	**A2**
	impulse = $F\Delta t$ = $\Delta\{mv\}$ **OR** (impulse =$F\Delta t$ =) $\Delta\{mv\}$ **OR** (impulse =) 0.046 × 41	C1
(b)(ii)	3800 N	**A2**
	$F=\Delta p / \Delta t$ **OR** (F=) Δp / (Δ)t **OR** (F=) $\Delta(mv)$ / (Δ)t **OR** (F =) impulse / (Δ)t **OR** 1.9 / 0.0005 **OR** 3.8×10^{N} N	C1

Q2.

(b)(i)	14 J	**A2**
	(E_k =) ½mv^2 **OR** ½ × 0.2(0) × 12^2	C1
(b)(ii)	$p = mv$ **OR** (Δp =) $mv - mu$	**B1**
	(Δp =) $0.2(0) \times \{14 + 12\}$ **OR** $0.2(0) \times \{14 - -12\}$ **OR** $p_{\text{before}} = 0.2(0) \times 14$ **AND** $p_{\text{after}} = 0.2(0) \times (-)12$	**B1**
	(Δp =) $2.8 - \{-2.4\}$ (= 5.2 kg m / s) **OR** (Δp =) $0.2(0) \times \{14 - -12\}$	**B1**
(b)(iii)	21 N	**A2**
	(F =) Δp / (Δ)t **OR** F = (Δ)mv / (Δ)t **OR** 5.2 / 0.25	C1

Q3.

Question	Answer		Marks
(a)(i)	force × time (for which force acts)		**B1**
(a)(ii)	0.056 Ns		**A3**
	$v = s / t$ OR $v = 0.67 / 0.18$ (m / s)		C1
	(impulse =) $\Delta\{mv\}$ **OR** (impulse =) $0.015 \times 0.67 / 0.18$ **OR** (impulse =) $15 \times 0.67 / 0.18$ **OR** (impulse =) 5.6×10^{N}		C1
(a)(iii)	(momentum is conserved as) air released from the balloon moves in the opposite direction to the balloon		**B1**
	momentum of balloon (and straw) is equal in size to momentum of air		**B1**
(b)	resultant force = 0.84 N	resultant force = 0.84 N	**A2**
	correct vector triangle or rectangle drawn	use of Pythagoras' theorem e.g. $a^2 + b^2 = c^2$ OR (force =) $\sqrt{(0.40^2 + 0.74^2)}$	C1
	direction 62° (below the horizontal)	direction 62° (below the horizontal)	**A2**
	correct resultant force vector with correct arrows on all vectors	use of trigonometry to find angle e.g. $\tan\theta = 0.74 / 0.40$	C1

Q4.

(b)(i)	1.2 N s	**A3**
	impulse = change in momentum **or** 2.0×0.60	C1
	$I = m\Delta v$ in any form **or** 2.0×0.60	C1
(b)(ii)		**B3**
	kinetic energy (of block A) decreases	B1
	thermal / internal energy produced / increases (due to friction)	B1
	friction mentioned **or** block slows down / decelerates	B1

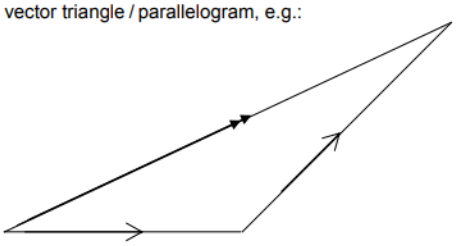
Q5.

Question	Answer	Marks
(a)	momentum before collision = momentum after collision	**B1**
	(initial momentum (p) =) 800×2 OR 1600 (kg m / s)	**B1**
	(v =) $(1600 - 1300) / 800$ OR $300 / 800$ OR 0.38 (m / s)	**B1**
(b)(i)	(impulse =) change in momentum	**C1**
	1300 Ns	**A1**
(b)(ii)	same value as **(b)(i)** OR 1300 (Ns)	**B1**

Q6.

Question	Answer	Marks
(a)(i)	0.078 N s **or** 0.078 kg m / s	**A2**
	(I =) $m_t(\Delta)v_t$ in any form **or** 1.2 × 0.065	**C1**
(a)(ii)	150 m / s	**A2**
	$v_b = (m_t + v_t) / m_b$ in any form **or** initial momentum = final momentum **or** 1.2(0052) × 0.065 / 0.00052 **or** 0.078(0338) / 0.00052	**C1**
(b)	work done against / due to / because of friction **or** kinetic energy (of trolley) used to do work	**B1**
	kinetic energy decreases (to zero)	**B1**
	thermal energy produced	**B1**

Q7.

Question	Answer	Marks
(a)	(p =) mv (in any form) **or** 0.16 × 15	**C1**
	2.4 kg m / s	**A1**
(b)(i)	3.0 N s **and** at 45° to the original direction	**B1**
(b)(ii)	vector triangle / parallelogram, e.g.: 	**B1**
	scale indicated **or** correct triangle / parallelogram	**B1**
	4.8 kg m / s ⩽ magnitude ⩽ 5.2 kg m / s	**B1**
	22° (to original direction) ⩽ direction ⩽ 28°(to original direction)	**B1**

Q8.

Question	Answer	Marks
(a)	impulse OR $\Delta p = m(v - u)$ in any form	**C1**
	(impulse =) 750 000 (84 – 42)	**C1**
	(impulse =) 3.2×10^7 N s or m kg / s	**A1**

Q9.

(c)(i)	no external forces **OR** isolated system	**B1**
	sum of momenta / (total) momentum remains constant	**B1**
(c)(ii)	rocket gains (upward) momentum	**B1**
	(ejected) gas gains equal (quantity of) momentum in opposite direction **OR** momentum of gas decreases by equal amount	**B1**

Q10.

Question	Answer	Marks
(a)	(Δ) p=mv in any form OR ((Δ)p=) mv OR 0.8 × 0.72	**C1**
	(Δp=) 0.58 kg m/s	**A1**
(b)	Ft= Δp in any form OR (F=) Δp/t OR 0.58/6	**B1**
	(F=) 0.096 N accept rounding if 0.096 seen	**B1**

Q11.

Question	Answer	Marks
(a)	Energy cannot be created or destroyed OR energy can only be transferred from one form to another OR total energy remains constant	**B1**
(b)(i)	Chemical (energy) to kinetic (energy) AND / OR potential (energy)	**B1**
	Any **one** of: Kinetic (energy) to potential (energy) OR gravitational (energy) Potential (energy) OR gravitational (energy) to kinetic (energy) Kinetic (energy) to thermal (energy) OR heat (energy)	**B1**
(b)(ii)1	(momentum =) mv OR 4.0 × 12	**C1**
	48 kg m/s or N s	**A1**
(b)(ii)2	(average force =) momentum change / time OR $m(v – u) / t$ OR $(mv – mu) / t$ OR $F = ma$ AND $a = (v – u) / t$ OR 48 / 0.60	**C1**
	80 N	**A1**

Q12.

Question	Answer	Marks
(a)	*mv* – *mu* or *mu* – *mv* in any form	**B1**
(b)(i)	(impulse =) *Ft* in any form	**C1**
	(impulse =) 2.4 Ns	**A1**
(b)(ii)	*Ft* = *mv* – *mu* in any form OR *(v – u =) Ft / m*	**C1**
	43 m / s	**A1**
(b)(iii)	1 kinetic energy (of racquet) to elastic / strain energy (in ball or strings)	**B1**
	2. elastic / strain energy (in ball or strings) to kinetic energy (of ball)	**B1**