CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Unit 5: Work, Energy and Power

Past Papers 2021 – 2025

MARK SCHEME 19 Questions

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Question 1 — Mark Scheme

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Question	Answer	Mark
2(a)	force × displacement in the direction of the force	B1
2(b)(i)	$E = \frac{1}{2}mv^2$	C1
	(m =) $23 \times 2 / 16^2 = 0.18$ (kg)	A1
2(b)(ii)	$(\Delta)E = mg(\Delta)h$ $60 = 0.18 \times 9.81 \times h$	C1
	$h = 34$ m	A1
2(b)(iii)	(work done =) 60 – 23 = 37 (J)	C1
	average resistive force = 37 / 34 = 1.1 N	A1
2(c)	air resistance (acting on ball) increases	B1
	resultant force (on ball) decreases or weight constant and air resistance increases	B1
	acceleration decreases	B1

Question 2 — Mark Scheme

Question	Answer	Mark
2(a)(i)	$P = Fv$	C1
	$= 18 \times 1.4$ $= 25\ \text{W}$	A1
2(a)(ii)	$a = F / m$	C1
	$a = 18 / 72 = 0.25\ (\text{m s}^{-2})$ $t = 1.4 / 0.25$	C1
	$= 5.6\ \text{s}$	A1
2(b)(i)	$a = (54 - 18) / 72$ **or** $36 / 72\ (= 0.50\ \text{m s}^{-2})$	C1
	$v^2 = 2 \times 0.50 \times 9.5$	C1
	$v = 3.1\ \text{m s}^{-1}$	A1
2(b)(ii)	$W = 54 \times 9.5$ $= 510\ \text{J}$	A1
2(b)(iii)	curved line from the origin	M1
	gradient of line increases	A1
2(c)	(force due to) air resistance increases/changes/not constant **or** air resistance increases with speed	B1

Question 3 — Mark Scheme

Question	Answer	Mark
3(a)	solid straight line drawn between centre of sphere at X and at Y	**B1**
3(b)	$p = mv$ **or** $0.72 = mv$	**C1**
	$E = \frac{1}{2}mv^2$ **or** $0.86 = \frac{1}{2}mv^2$	**C1**
	$(m =)\ 0.72^2 / (2 \times 0.86) = 0.30$ (kg) **or** $v = 2E_K / p$ $v = (0.86 \times 2) / 0.72 = 2.4$ (to 2 s.f.) $m = 0.72 / 2.4 = 0.30$ (kg)	**A1**
3(c)	$(\Delta)E = mg(\Delta)h$	**C1**
	$h = 0.86 / (0.30 \times 9.81)$ $= 0.29$ m	**A1**
3(d)	$\cos\theta = (0.93 - 0.29) / 0.93$ so $\theta = 47°$	**A1**
3(e)	moment $= (0.30 \times 9.81) \times 0.93 \times (\sin 47°$ **or** $\cos 43°)$ **or** moment $= (0.30 \times 9.81) \times [0.93^2 - (0.93 - 0.29)^2]^{0.5}$	**C1**
	$= 2.0$ N m	**A1**

Question	Answer	Mark
3(f)	there is a resultant force (acting on sphere) **or** there is a resultant moment (about P acting on pendulum) (so) not in equilibrium	**B1**

Question 4 — Mark Scheme

Question	Answer	Marks
3(a)	$(\Delta)E = mg(\Delta)h$ **or** $W(\Delta)h$	**C1**
	$= 330 \times (4.0 - 1.1)$ $= 960$ J	**A1**
3(b)	(work =) $960 - 540$ $(= 420$ J)	**C1**
	distance moved = $(960 - 540) / 52$ $= 8.1$ m	**A1**
3(c)(i)	$E = \frac{1}{2}mv^2$	**C1**
	$540 = \frac{1}{2} \times (330 / 9.81) \times v^2$ $v = 5.7$ m s^{-1}	**A1**
3(c)(ii)	speed = horizontal component of velocity $= 5.7 \times \cos 41°$	**C1**
	$= 4.3$ m s^{-1}	**A1**

Question 5 — Mark Scheme

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Question	Answer	Marks
3(a)	work (done) / time (taken)	**B1**
3(b)(i)	zero / 0 J	**A1**
3(b)(ii)	work done = 440×25 = 1.1×10^4 J	**A1**
3(c)(i)	$(\Delta)E_{(P)} = mg(\Delta)h$	**C1**
	h = $4.8 \times 10^4 / (1700 \times 9.81)$ = 2.9 m	**A1**
3(c)(ii)	θ = $\sin^{-1}(2.9 / 25)$ = 6.7°	**A1**
3(d)	work done = $4.8 \times 10^4 + 1.1 \times 10^4$ ($= 5.9 \times 10^4$ J)	**C1**
	time = $5.9 \times 10^4 / 1.7 \times 10^4$ = 3.5 s	**A1**

Question 6 — Mark Scheme

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Question	Answer	Marks
2(a)	force × displacement in the direction of the force	**B1**
2(b)	units: kg m s^{-2} × m = kg m^2 s^{-2}	**A1**
2(c)	T_1: K and T_2: K	**C1**
	A: m^2 and t: s and L: m	**C1**
	c = (kg m^2 s^{-2} m) / (m^2 K s) = kg m s^{-3} K^{-1}	**A1**

Question 7 — Mark Scheme

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Question	Answer	Marks
4(a)	ratio = 300 / 3200 = 0.094	A1
4(b)	$E = \frac{1}{2}mv^2$ or $E \propto v^2$	C1
	ratio = $(0.094)^{0.5}$ = 0.31	A1
4(c)	work (done against frictional force) = 3200 – 300 (=2900)	C1
	length = 2900 / 76 = 38 m	A1
4(d)(i)	$E = \frac{1}{2}kx^2$ or $E = \frac{1}{2}Fx$ and $F = kx$ $140 = \frac{1}{2} \times 63 \times x^2$ or $140 = \frac{1}{2}Fx$ and $F = 63x$	C1
	x = 2.1 m	A1
4(d)(ii)	percentage efficiency = (140 / 300) × 100 = 47%	A1
4(d)(iii)	curved line from the origin	M1
	gradient of line increases	A1

Question 8 — Mark Scheme

Question	Answer	Marks
3(a)(i)	work (done) / time (taken)	**B1**
3(a)(ii)	$W = Fx$ **or** $E = Fx$	**B1**
	$(P =)\ Fx / t = Fv$ **or** $P = Fvt / t = Fv$	**B1**
3(b)(i)	$T = 430 \sin 11°$ **or** $430 \cos 79°$	**C1**
	$= 82$ N	**A1**
3(b)(ii)	speed $= 56 / 82$ $= 0.68\ \text{m s}^{-1}$	**A1**
3(b)(iii)	no change in kinetic energy (of block)	**B1**
3(b)(iv)	(input power) $= 56 / 0.80$ $(= 70$ W)	**C1**
	time taken $= 1.2 \times 10^3 / 70$ $= 17$ s	**A1**
	or	
	(useful energy) $= 1200 \times 80 / 100$ $(= 960$ J)	**(C1)**
	time taken $= 960 / 56$ $= 17$ s	**(A1)**

Question 9 — Mark Scheme

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Question	Answer	Marks
4(a)	work (done) = force × displacement	**M1**
	(force = mg and distance = Δh) (so) work (done) = $mg\Delta h$ and work = $\Delta E_{(P)}$ (so $\Delta E_{(P)} = mg\Delta h$)	**A1**
4(b)	gravitational potential (energy) to heat/thermal (energy)	**B1**
4(c)(i)	$P = mg(\Delta)h / (\Delta)t$ **or** Fv	**C1**
	$P = (0.60 \times 9.81 \times 1.4) / 4.0$ **or** $0.60 \times 9.81 \times (1.4 / 4.0)$ $= 2.1$ W	**A1**
4(c)(ii)	$P = I^2R$ **or** IV **or** V^2 / R	**C1**
	$= 0.09^2 \times 47$ **or** 0.09×4.23 **or** $4.23^2 / 47$ $= 0.38$ W	**A1**
4(c)(iii)	efficiency = P_{out} / P_{in} (× 100) **or** E_{out} / E_{in} (× 100)	**C1**
	$= 0.38 / 2.1$ (× 100) **or** $0.38 \times 4.0 / 2.1 \times 4.0$ (× 100) $= 0.18$ **or** 18%	**A1**

Question 10 — Mark Scheme

Question	Answer	Marks
3(a)(i)	work done per unit time	**B1**
3(a)(ii)	$W = Fs$	**B1**
	$P = Fs / t$ and (so) $P = Fv$	**B1**
3(b)	(F =) $130 \times 10^3 / 25 = 5200$ (N)	**A1**
3(c)(i)	(component of weight =) $mg \sin\theta$	**A1**
3(c)(ii)	F (along slope due to weight) $= 36\,000 \times 9.81 \times \sin 1.4°$ (= 8600 N)	**C1**
	(total) $F = 5200 + 36\,000 \times 9.81 \times \sin 1.4°$ (= 13 800 N)	**C1**
	$P = 13\,800 \times 25$ $= 350 \times 10^3$ (W) = 350 kW	**A1**

Question 11 — Mark Scheme

2(c)(i)	$((\Delta)E) = mg(\Delta)h$ **or** $W(\Delta)h$	**C1**
	$= 0.30 \times 0.090$ $= 0.027$ J	**A1**
2(c)(ii)	$E = \frac{1}{2}mv^2$	**C1**
	$E = 0.044 - 0.027$ (= 0.017)	**C1**
	$v^2 = (2 \times 0.017) / (0.30 / 9.81)$ (where v = speed at A) $v = 1.1$ m s^{-1}	**A1**
	or	
	$E = \frac{1}{2}mv^2$	**(C1)**
	$0.044 = \frac{1}{2} \times (0.30 / 9.81) \times v^2$ (where v = speed at B) $(v^2 = 2.88)$ $v^2 = u^2 + 2as$ (where u = speed at A) $2.88 = u^2 + 2 \times 9.81 \times 0.090$	**(C1)**
	$u = 1.1$ m s^{-1}	**(A1)**
2(c)(iii)	(gravitational / resultant) force / weight is vertical	**B1**
2(c)(iv)	straight line with positive gradient starting from non-zero value of v_Y at time t_A to a time t_B	**B1**

Question 12 — Mark Scheme

Question	Answer	Marks
4(a)	$\rho = m / V$ **or** $\rho = m / Ah$	**B1**
	$p = F / A$ **or** $p = W / A$	**B1**
	appropriate algebra leading to $p = \rho gh$ e.g. $p = \rho Ahg / A$ **or** $\rho Vg / A$ **or** $\rho Vg / (V/h)$ **and** (so) $p = \rho gh$	**B1**
4(b)	there is atmospheric / air pressure	**B1**
4(c)	$\Delta p = \rho g \Delta h$ e.g. $(9.66 - 9.60) \times 10^4 / 8.0 \times 10^{-2} = \rho \times 9.81$	**C1**
	$\rho = 760 - 770$ kg m^{-3}	**A1**

Question 13 — Mark Scheme

2(c)(i)	$(\Delta)E = mg(\Delta)h$ **or** $W(\Delta)h$	**C1**
	$= 2.4 \times 1.8$ $= 4.3$ J	**A1**

Question	Answer	Marks
2(c)(ii)	$E = \frac{1}{2}mv^2$	C1
	$= \frac{1}{2} \times (2.4 / 9.81) \times 3.4^2$ $= 1.4$ J (at X)	C1
	kinetic energy at Y $= 4.3 + 1.4$ $= 5.7$ J	A1
	or	
	$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + mg(\Delta)h$	(C1)
	$v^2 = 3.4^2 + 2 \times 9.81 \times 1.8$ $v^2 = 46.9$ so $v = 6.85$ (m s^{-1}) KE $= \frac{1}{2} \times (2.4 / 9.81) \times 6.85^2$	(C1)
	$= 5.7$ J	(A1)
2(c)(iii)	no variation **or** acceleration is (always) vertically downwards	B1
2(c)(iv)	horizontal straight line at a non-zero value of velocity	B1

Question 14 — Mark Scheme

Question	Answer	Marks
3(a)	product of force and displacement in direction of force	**B1**
3(b)	weight/force = mg, and g identified as acceleration of free fall	**B1**
	ΔE_P identified as work (done by lifting force/weight), and so = $mg \times \Delta h$	**B1**
3(c)(i)	$240 \times 150 = 36$ kJ	**A1**
3(c)(ii)	$P = W / t$	**C1**
	= 36 000 / 60 = 600 W	**A1**
3(c)(iii)	efficiency = <u>useful</u> output power / total input power	**C1**
	= 600 / 900 = 0.67	**A1**
3(c)(iv)	$P = I^2R$ **and** $R = \rho L / A$	**C1**
	$280 = I^2 \times (1.7 \times 10^{-8} \times 23) / (2.6 \times 10^{-8})$	**C1**
	$I = 4.3$ A	**A1**

Question 15 — Mark Scheme

Question	Answer	Marks
3(a)	work done per unit time	**B1**
3(b)(i)	$P = F \times v$ $= 1750 \times 35$	**C1**
	$= 6.1 \times 10^4$ W	**A1**
3(b)(ii)	$W = Fs$ $= 1750 \times 17\,000$	**C1**
	$= 3.0 \times 10^7$ J	**A1**
	or $W = Pt$ $= 6.1 \times 10^4 \times (17\,000 / 35)$	**(C1)**
	$= 3.0 \times 10^7$ J	**(A1)**

Question	Answer	Marks
3(b)(iii)	$P = V \times I$ Power in = $600 \times I$	**C1**
	Efficiency = $\frac{\text{useful power output}}{\text{(total) power input}}$	**C1**
	$0.85 = 6.1 \times 10^4 / (600 \times I)$ I = 120 A	**A1**
3(c)(i)	Air resistance is the same, as the speed is the same	**B1**
3(c)(ii)	The motor is producing less power (because of gravitational force / conversion of gravitational potential energy to kinetic energy) so the current will be smaller.	**B1**

Question 16 — Mark Scheme

1(b)(i)	$W = Fs$ **or** $W = mas$	**B1**
	$s = v^2 / 2a$ **or** $a = v^2 / 2s$ **or** $as = v^2 / 2$	**B1**
	$W = ma(v^2 / 2a)$ **or** $W = m(v^2 / 2s)s$ **or** $W = m(v^2 / 2)$ **and** (so E_K)= $½mv^2$	**B1**
	OR $W = Fs$ or $W = mas$	**(B1)**
	$F = mv / t$ **and** $s = ½vt$	**(B1)**
	$W = mv / t \times ½vt$ **and** (so E_K)= $½mv^2$	**(B1)**
	OR $W = Fs$ or $W = mas$	**(B1)**
	$a = v / t$ **and** $s = ½vt$	**(B1)**
	$W = m(v / t)(½vt)$ **and** (so E_K)= $½mv^2$	**(B1)**
	OR $W = Fs$ **or** $W = mas$	**(B1)**
	$a = v / t$ **and** $s = ½at^2$	**(B1)**
	$W = m(v / t)(½ \times (v / t) \times t^2)$ **and** (so E_K)= $½mv^2$	**(B1)**

Question	Answer	Marks
1(b)(ii)	kinetic energy $= \frac{1}{2} mv^2$ $= \frac{1}{2} \times 920 \times 17^2$ $= 1.3 \times 10^5$ J	**A1**
1(b)(iii)	$P = W/t$	**C1**
	$= (4.7 \times 10^4 + 1.3 \times 10^5) / 5.8$	**C1**
	$= 3.1 \times 10^4$ W	**A1**
1(b)(iv)	(at/after t = 5.8 s) the kinetic energy (of the car) does not change / work is done only against resistive forces / no work is done to accelerate (the car) so (power output is) less	**B1**

Question 17 — Mark Scheme

Question	Answer	Marks
3(a)	$W = Fd$	**B1**
	$P = Fd / t = Fv$ **or** $P = Fvt / t = Fv$	**B1**
3(b)(i)	$(\Delta)E_{(P)} = mg(\Delta)h$	**C1**
	increase of gravitational potential energy of car in 1.0 s $= 1500 \times 9.81 \times 30 \times \sin 6.0 = 46\,000$ J	**A1**

Question	Answer	Marks
3(b)(ii)	(Power to overcome total resistive forces) $= 1600 \times 30$ $= 48\,000$ W	**C1**
	power $= 48\,000 + 46\,000$ $= 9.4 \times 10^4$ W	**A1**
3(c)(i)	Air resistance is the same, as the speed is the same	B1
3(c)(ii)	Mass / weight has increased so (power will) increase	**B1**

Question 18 — Mark Scheme

Question	Answer	Marks
4(a)	sum / total momentum (of a system of bodies) is constant **or** sum / total momentum before = sum / total momentum after	**M1**
	for an isolated system / no (resultant) external force	**A1**
4(b)(i)	$p = mv$ **or** 4.0×6.0 or 2.0×3.0 $(4.0 \times 6.0) + (2.0 \times 3.0) = 6.0 \times v$	**C1**
	so $v = 5.0\ \text{m s}^{-1}$	**A1**

Question	Answer	Marks
4(b)(ii)	KE before $= (0.5 \times 4.0 \times 6.0^2) + (0.5 \times 2.0 \times 3.0^2)$ $= 81\ \text{J}$	**C1**
	KE after $= (0.5 \times 6.0 \times 5.0^2)$ $= 75\ \text{J}$	**(C1)**
	percentage transferred $= [(81 - 75) / 81] \times 100$ $= 7\%$	**A1**

Question 19 — Mark Scheme

Question	Answer	Marks
3(a)	$E_{(K)} = \frac{1}{2}mv^2$ $110 = \frac{1}{2} \times 5.5 \times v^2$	C1
	$v = 6.3\ \text{m s}^{-1}$	A1
3(b)	$(\Delta)E_{(P)} / 20 = mg(\Delta)h$ OR $(\Delta)E_{(P)} / 20 = mgx_0$	C1
	$(x_0 =)\ 20 / 5.5 \times 9.81 = 0.37$ (m) Allow $(\Delta)h$ for x_0	A1
3(c)	[max $(E_{(P)})$] = 110 + 20 = 130 J	A1

Question	Answer	Marks
3(d)	(max) $E_{(P)} / 130 = \frac{1}{2} F_{(0)} x_{(0)}$	C1
	$(F_0 =) 2 \times 130 / 0.37 = 700$ (N)	A1
	or (max) $E_{(P)} / 130 = 1 / 2k\, x_{(0)}^2$ $(F_0 =) k\, x_{(0)}$	(C1)
	$(F_0 =) 2 \times 130 \times 0.37 / (0.37)^2 = 700$ (N)	(A1)
3(e)(i)	(weight) $= 5.5 \times 9.81$	C1
	resultant force $= 700 - (5.5 \times 9.81)$ $= 650$ N	A1
3(e)(ii)	$F = ma$	C1
	$a = 650 / 5.5$ **or** $(700 / 5.5) - 9.81$ $a = 120$ m s^{-2}	A1