PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



MARK SCHEME

SECTION 1: FORCES AND MOTION (PACK 2)

SCORE	PERCENTAGE
/314	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a) (i)	GPE = mass × g × height;	allow standard symbols and rearrangements e.g. GPE = m × g × h	1
(ii)	substitution; evaluation; e.g. (GPE =) 0.52 × 10 × 0.82 (GPE =) 4.3 (J)	allow use of g = 9.8, 9.81 -1 for clear POT error allow 4.2, 4.26, 4.264, 4.17872, 4.18...	2
(iii)	identical answer to (ii);	allow ecf from (ii) expect 4.3 (J)	1
(iv)	selection of KE = ½ × mass × speed^2; substitution; rearrangement; evaluation; e.g. KE = ½ × m × v^2 4.3 = ½ × 0.52 × v^2 v = √[2 × 4.3 / 0.52] (v =) 4.1 (m/s)	seen or implied allow ecf from (iii) allow alternative method using v^2 = u^2 + 2as allow 4.0-4.1 (m/s)	4
(b)	any three from: MP1. oil is more dense / viscous (than air); MP2. force of friction now present / greater (than before); MP3. ball now does work against friction; MP4. decrease in GPE same as before; MP5. idea that energy is conserved; MP6. some energy transferred to thermal store (of air/ball); MP7. means less energy transferred to KE;	 allow oil is thicker allow drag, fluid/liquid resistance for friction allow upthrust is greater ignore resistance	3
		Total for question = 11 marks	

Q2.

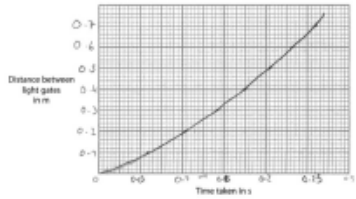
Question number	Answer	Notes	Marks
(a)	use of u=0 (m/s); correct substitution into '$v^2 = u^2 + 2aS$'; correct evaluation of v^2; correct evaluation of v; correct answer = 160 (m/s) e.g. $v^2 = u^2 + 2aS$ $v^2 = 0^2 + (2 \times 10 \times 1300)$ $v^2 = 26000$ v = 161.245... (m/s)	accept loss of GPE = gain in KE reject use of v=0 for this MP $v^2 = 26000$ accept 25506, 25480 reject $v^2 = 2600$ if no a=10 seen. ignore sign accept 159.7059..,159.62....	4
(b) (i)	any THREE from: MP1. reference to weight **and** air resistance; MP2. air resistance larger than weight (when parachute opens); MP3. reference to 'F = ma'; MP4. acceleration is upwards; MP5. air resistance decreases as parachutist slows down;	ignore 'upthrust' accept drag for AR accept 'resultant or unbalanced force is upwards ' allow idea of increased AR ignore 'decelerates' or 'slows down'	3
(ii)	any THREE from: MP1. GPE reduces as height above ground reduces; MP2. KE reduces as speed reduces; MP3. friction force does mechanical work on parachutist; MP4. thermal store of parachutist increases; MP5. thermal transfer between (warm) parachutist and (cold) air; MP6. thermal transfer happens by conduction or radiation;	 accept 'works mechanically' accept 'energy lost to the surroundings' accept idea of conversion to heat energy via friction	3
		(Total for Question = 10 marks)	

Q3.

Question number	Answer	Notes	Marks
(a) (i)	air resistance / drag;	allow friction ignore resistance, wind resistance	1
(ii)	(unbalanced) force = mass × acceleration;	allow rearrangements and standard symbols e.g. a = F / m	1
(iii)	substitution OR rearrangement; evaluation; e.g. 2900 = 1200 × a OR a = F / m (a =) 2.4 (m/s²)	 allow 2.42, 2.416... condone 2.41	2
(b) (i)	idea that condition of brakes has no effect on thinking distance; idea that the greater the speed, the greater the thinking distance;		2
(ii)	distance = area under graph; attempt at evaluating area of triangular section; correct evaluation; e.g. distance = area under graph distance = ½ × 2.5 × 18 (distance =) 23 (m)	can be stated explicitly or implied from working allow even if there is a minor error in reading graph scales e.g. distance = ½ × 2.5 × 16 31.5 (m) scores 2 marks (working out entire area under line) allow 22.5 (m) 22 (m) scores 2 marks only	3
			Total for question = 9 marks

Q4.

Question number	Answer	Notes	Marks
(a) (i)	substitution into $a = \Delta v / t$; evaluation to 3 or more s.f.; e.g. acceleration = (4.20 - 1.45) / 0.286 (acceleration =) 9.62 (m/s^2)		2
(ii)	idea that air resistance / friction also acts on ball; which opposes the ball's weight;	allow drag allow idea that frictional force is upwards whilst weight is downwards allow idea that resultant force is less that weight ignore idea of reaction time / other human errors	2
(iii)	substitution into $v^2 = u^2 + 2 \times a \times s$; rearrangement; evaluation; e.g. $4.20^2 = 1.45^2 + (2 \times 9.6 \times s)$ $s = (v^2 - u^2) / 2a$ (s =) 0.809 (m)	allow use of a=9.6, 9.8, 9.81 or 10 reject 'change in speed × time' giving 0.78(65) as incorrect physics allow answers using correct average velocity. allow range 0.78-0.81 (m)	3

(b)	(i)	suitable scale on both axes; all points plotted correctly to nearest half square; 		2
	(ii)	smooth curve drawn with an even distribution of data points either side;	ECF candidate plotting	1
	(iii)	gradient of graph is equal to the speed / velocity of the ball; gradient is increasing (as time increases); speed / velocity is increasing (as time increases);	 allow "curve gets steeper" allow idea of greater distance in a unit of time DOP award 1 mark for idea that graph is a curve if no other marks awarded	3

Q5.

Question number	Answer	Notes	Marks
(a) (i)	acceleration = **change in** velocity / time (taken);	allow standard symbols and rearrangements e.g. a = v-u / t allow Δv reject a = v / t	1
(ii)	substitution; rearrangement; evaluation; e.g. 1.6 = 22-14 / t t = 22-14 / 1.6 (t =) 5.0 (s)	 allow 5 (s)	3
(iii)	(unbalanced) force = mass × acceleration;	allow standard symbols and rearrangements e.g. F = m × a	1
(iv)	substitution; evaluation; evaluation correctly rounded to 2s.f.; e.g. F = 1200 × 1.6 (F =) 1920 (N) (F =) 1900 (N)	 mark independently	3
(b)	idea that the car slows down; due to friction / air resistance / drag;	allow idea that car becomes stationary ignore "motion decreases"	2

Q6.

Question number	Answer	Notes	Marks
(a) (i)	any attempt to find gradient of graph; use of two points on the line to calculate gradient; evaluation; e.g. acceleration = gradient acceleration = (−)4.2 / 0.45 (acceleration =) −9.3 (m/s^2)	allow use of acceleration formula allow reading of pair of velocities with matching time interval reject positive answer allow −9.3 to −9.4	3
(ii)	 any clear indication that distance travelled = area; correct use of data from graph; evaluation; e.g. distance = area distance = 0.5 × 0.45 × 4.2 (distance =) 0.95 (m)	accept alternative method using $v^2 = u^2 + 2as$ with acceleration calculated in (i) allow attempt to calculate area of triangle allow 0.94, 0.945 (m)	3

(b)	(i)	weight / gravitational force; drag / air resistance;	ignore unqualified 'gravity', gravitational field strength ignore upthrust, lift	2
	(ii)	one upward arrow and one downward arrow drawn; arrows originate at object; downward arrow drawn longer than upward arrow;	judge by eye judge by eye	3
	(iii)	any four from: MP1. object is accelerating (from A to B); MP2. downward force greater than upward force (at A); MP3. gradient / acceleration decreasing (from A to B); MP4. drag increases as speed increases; MP5. resultant force decreases; MP6. idea that (just after) B, downward force = upward force; MP7. idea that in region BC, acceleration is zero/close to zero; MP8. terminal velocity achieved in region BC;	 allow speeding up allow any recognisable upward force and downward force allow any recognisable upward force and downward force allow constant velocity	4

Q7.

Question number	Answer	Notes	Marks
(a) (i)	(average) speed = distance (travelled) ÷ time (taken);	allow standard symbols and rearrangements e.g. v = s / t allow s, d for distance condone s for speed	1
(ii)	substitution OR rearrangement; evaluation; e.g. 21 = distance / 0.14 OR s = v × t (distance =) 2.9 (m)	 allow 3, 2.94 (m)	2
(b) (i)	force = mass × acceleration;	allow standard symbols and rearrangements e.g. a = F / m	1
(ii)	substitution OR rearrangement; evaluation; e.g. 7600 = 1200 × a OR a = F / m (a =) (−)6.3 (m/s^2)	 allow 6.33... (m/s^2)	2
(iii)	substitution into $v^2 = u^2 + 2as$; rearrangement; evaluation; e.g. $0^2 = 21^2 + [2 \times (-)6.3 \times \text{distance}]$ distance = 441 / 12.6 distance = 35 (m)	ecf answer from (ii) allow 34.8...(m)	3

Q8.

Question number		Answer	Notes	Marks
(a)	(i)	(average) speed = distance (moved) / time (taken);	allow standard symbols and rearrangements e.g. v = s / t allow s for speed, d for distance	1
	(ii)	substitution; evaluation; e.g. (speed =) 6.5 / 0.25 (speed =) 26 (m/s)		2
	(iii)	correct conversion of EITHER m to km OR s to h; full conversion from m/s to km/h AND consistent conclusion;;	allow ECF from (ii) allow ECF from (ii) allow conversion of km/h to m/s e.g. 80km/h = 22.2m/s	2
		e.g. 26 (m/s) = 0.026 (km/s) OR 26 (m/s) = 93600 (m/h) 94 (km/h) => too fast	 allow 93.6 (km/h)	
(b)	(i)	acceleration is the gradient (of the graph); graph has a constant gradient;	 allow line on graph is straight	2
	(ii)	acceleration = change in velocity / time;	allow standard symbols and rearrangements e.g. a = (v-u) / t, a = Δv / t	1
	(iii)	correct reading of either two velocity values or time interval taken from graph; correct substitution into formula; evaluation; e.g. u = 5 (m/s), v = 24 (m/s) OR t = 60 (s) (a =) 24-5 / 60 (a =) 0.32 (m/s^2)	allow attempt at gradient calculation allow (v – u =) 19 seen allow range of 0.30-0.32	3

Q9.

Question number	Answer	Notes	Marks
(a)	Callisto drawn with a circular orbit around Jupiter; Jupiter positioned at the centre of the orbit;	judge circular shape by eye	2
(b)	conversion of time from hours to seconds; substitution into orbital speed formula; evaluation; final answer given to 3s.f.; e.g. time = (400 × 60 × 60 =) 1 440 000 (s) (orbital speed =) 2 × π × 1 880 000 / 1 440 000 (orbital speed =) 8.203... (km/s) (orbital speed =) 8.20 (km/s)	allow use of 1 440 000 seen anywhere allow ecf from incorrect time conversion mark independently	4
(c) (i)	any one from: MP1. Callisto has a larger radius; MP2. Callisto has a lower density; MP3. Callisto has a smaller core;	allow RA allow Callisto is larger ignore references to orbital radius/distance from Sun	1
(ii)	use of weight = mass × g; setting up ratio OR evaluation of mass of object; evaluation of weight on Callisto; e.g. $W = m \times g$ $W_c / g_c = W_m / g_m$ OR m = 37 (kg) (W_c =) 44 (N)	seen anywhere in working answer of 78-79 gets 2 marks allow 44.3, 44.25	3
		Total for Question = 10 marks	

Q10.

Question number	Answer	Notes	Marks
(a)	any five from: MP1. measure original length of spring; MP2. measure new length / extension for a **range** of masses; MP3. extension = new length - original length; MP4. use of ruler; MP5. **method** of avoiding parallax, e.g. look at eye level or use a pointer; MP6. use of a set square / clamping ruler vertically; MP7. idea of measuring between the same two points (on the spring); MP8. idea of repeating and averaging; MP9. idea of measuring extension with decreasing mass as well;	allow any marking points if seen on diagram allow tape measure allow repeating to identify anomalies	5

(b)	(i)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and units; all plotting correct to nearest half square;	ignore orientation | Force in N	Extension in cm
---	---
0.0	0.0
1.0	2.5
2.0	5.0
3.0	9.8
4.0	10.0
5.0	12.5
6.0	15.5
7.0	19.5		3
	(ii)	data point at (3.0,9.8) identified;	allow (7.0,19.5) as chosen point	1
	(iii)	straight line of best fit passing through origin and non-anomalous points;	ecf from plotting in (i) ignore line beyond 6.0N	1
	(iv)	any three from: MP1. quotation of Hooke's Law; MP2. line is straight; MP3. line passes through origin; MP4. no evidence of having passed elastic limit;	 i.e. force and extension should be proportional allow idea that line is not straight if consistent with (iii) allow idea that elastic limit has been reached if consistent with (iii)	3

Q11.

Question number	Answer	Notes	Marks
(a) (i)	as pressure increases, volume decreases; pattern statement relating to gradient; e.g. 'at a decreasing rate'	ORA 'inversely proportional' scores 2 marks.	2
(ii)	pressure = depth × gravitational field strength × density;	allow recognised symbols e.g. P or p for pressure d or h for depth ρ for density reject d for density, reject gravity for g	1
(iii)	substitution; evaluation; e.g. pressure = 0.22 × 10 × 1080 pressure = 2 400 (Pa)	 Accept use of g=9.8(1) (N/kg) 2376 (Pa) -1 for POT error provided *g* is used	2
(iv)	103 000 (Pa)	accept 103 400 (Pa) allow ECF	1
(v)	substitution into given formula; rearrangement; evaluation; e.g $p_1 \times V_1 = p_2 \times V_2$ 101 000 × 0.084 = 103 000 x V_2 V_2 = 0.082 (cm^3)	allow ECF from (iv) e.g. 98624 gives 0.086 (cm^3) 0.082368932 -1 for POT error	3
(b)	vertical arrow upwards labelled upthrust; vertical arrow downwards labelled weight; upthrust > weight;	 ignore drag reject this mark if there are more than two arrows	3
		(Total for Question = 12 marks)	

Q12.

Question number	Answer	Notes	Marks
(a) (i)	(average) speed = distance (moved) / time (taken);	allow rearrangements and use of standard symbols e.g. v = s/t condone s = d/t	1
(ii)	use of one correct pair of readings from the graph; substitution of a correct distance and time into formula; evaluation; matching unit; e.g. total distance = 700 (km), total time = 60 (mins) (speed =) 400 / 30 (speed =) 13 km/minute	seen anywhere in working must be consistent with units used in substitution 400 000 / 1800 222 m/s 0.222 km/s gains 4 marks 800 km/hour gains 4 marks 12 km/minute gains 2 marks only 194 m/s gains 2 marks only	4
(b)	pressure increases; air molecules move faster / gain KE; molecules collide more often with aeroplane;	 allow temperature proportional to KE allow idea that air becomes more dense at lower height / RA ignore molecules colliding with each other allow molecules colliding with aeroplane with more force / harder	3
			Total for question 3 = 8 marks

Q13.

Question number	Answer	Notes	Marks
(a) (i)	0.9 (s);		1
(ii)		allow ECF from incorrect time found in (a)(i)	4
	distance = area (under line);	can be implied from calculation, explicit statement or working on graph itself	
	thinking distance (rectangle) = 13.5 (m) OR braking distance (triangle) = 23.25 (m) correctly determined;		
	attempt at calculating area of a trapezium / adding values for areas of rectangle and triangle;		
	(stopping distance =) 37 (m);	allow 36.75, 36.7, 36.8	
(iii)	acceleration formula seen in working;	can be implied from substitution of data	3
	correct substitution into acceleration formula;	allow ECF from incorrect time found in (a)(i)	
	evaluation of acceleration;	reject if given as a positive value	
	e.g. (acceleration =) change in velocity ÷ time	allow (a =) v-u ÷ t allow acceleration is gradient condone change in speed ÷ time	
	(acceleration =) (−)15 / 3.1		
	(acceleration =) −4.8 (m/s^2)	allow any answer that rounds to −4.8 allow deceleration = 4.8 (m/s^2)	

(b)	max. two factors linked to thinking distance:	allow 'reaction time' if no other thinking distance mark achieved ignore factors affecting visibility	4
	MP1. tiredness (of driver);		
	MP2. age (of driver);		
	MP3. alcohol or drug consumption;	e.g. caffeine, medicine etc.	
	MP4. distraction (of driver);	e.g. using a mobile phone etc.	
	max. two factors linked to braking distance:	ignore bald "the weather"	
	MP5. mass / weight of car;	allow however expressed e.g. more people, less luggage etc.	
	MP6. condition of brakes;		
	MP7. condition of road;	e.g. icy road, wet road	
	MP8. condition of tyres;	e.g. how much grip left / eq	
	MP9. slope of road;	e.g. whether the car is going up or downhill	

Q14.

Question number	Answer	Notes	Marks
(a) (i)	(unbalanced) force = mass × acceleration;	allow standard symbols and rearrangements e.g. F = m × a	1
(ii)	substitution; rearrangement; evaluation to at least 2s.f.; e.g. 223(000) = 10600 × acceleration acceleration = 223(000) / 10600 acceleration = 21.03...(m/s^2)	ignore units ignore units reject if ×1000 performed at the end of calculation allow 21, 21.0, 21.04 (m/s^2)	3
(b)	substitution into a = v-u / t; rearrangement; evaluation; e.g. 20 = 330 (-0) / time time = 330 / 20 (time =) 17 (s)	 allow 15-17 (s)	3
		Total for question = 7 marks	

Q15.

Question number	Answer	Notes	Marks
(a)	(quantity that has both) magnitude and direction;	allow size, value, number or amount for magnitude ignore scale for magnitude	1
(b)	vertically downward arrow drawn; labelled weight; arrow drawn in opposite direction to velocity; labelled air resistance / drag / <u>air</u> friction;	ignore starting points and lengths of arrows 3 marks max. if more than two arrows drawn judge by eye dependent on previous mark being awarded (DOP) allow gravitational force, force of gravity ignore gravity, gravitational field strength, gfs DOP but allow if arrow pointing to the left condone wind resistance	4
		Total for Question = 5 marks	

Q16.

Question number	Answer	Additional guidance	Mark
(a)	• downward arrow labelled 'weight' (1) • upward arrow labelled 'reaction' (1) • both arrows of approximately equal length and drawn in line within ball (1)	ignore 'gravity' allow 'gravitational force', 'force due to gravity' allow 'normal reaction force', 'normal contact force'	3

Question number	Answer	Additional guidance	Mark
(b)	Process should include: • substitution • rearrangement • evaluation to at least 2 significant figures (s.f.) e.g. $v^2 = 0 + (2 \times 10 \times 1.3)$ (1) $v = \sqrt{2 \times 10 \times 1.3}$ (1) $v = 5.1$ (m/s) (1)	allow 5.10, 5.099, 5.09	3

Question number	Answer	Additional guidance	Mark
(c)(i)	0.51 (seconds)	allow value in range 0.50–0.52 (seconds)	1

Question number	Answer	Additional guidance	Mark
(c)(ii)	Average speed = distance moved/time taken	allow in accepted symbols or rearranged.	1

Question number	Answer	Additional guidance	Mark
(c)(iii)	(Speed =) 2.0 (m/s)	accept 2	1

Question number	Answer	Mark
(c)(iv)	An explanation that makes reference to the following points: • gradient is equal to the {speed/velocity} of the ball (1) • gradient is increasing over time (1) • (therefore) the {speed/velocity} is increasing with time (1)	3

(Total for question = 12 marks)

Q17.

Question number	Answer	Notes	Marks
(a) (i)	downward force arrow labelled "weight"; upward force arrow labelled "drag" / "air resistance"; upward force larger than downward force by eye;	ignore starting position of arrows and any horizontal arrows allow "gravitational force", "gravitational pull", "force of gravity" reject "gravity" allow "friction" ignore "upthrust"	3
(ii)	any four from: MP1. air resistance increases (greatly) when parachute is opened; MP2. idea that air resistance is greater than weight; MP3. (therefore) resultant force is upwards; MP4. idea that as speed decreases, air resistance decreases; MP5. resultant force (eventually) becomes zero; MP6. constant speed achieved;	allow "drag" for air resistance throughout condone "gravity" for weight throughout allow "upwards force" for air resistance allow upward force is bigger than downward force allow deceleration / upwards acceleration ignore "it slows down" allow forces are balanced/equal air resistance = weight allow idea that there is no acceleration	4

(b)	attempted use of $v^2 = u^2 + (2 \times a \times s)$; correct substitution; rearrangement of formula / evaluation of v^2; evaluation of v; e.g. $v^2 = u^2 + (2 \times a \times s)$; $v^2 = 0.45^2 + (2 \times 3.4 \times 2.0)$; $v = \sqrt{(0.45^2 + (2 \times 3.4 \times 2.0))}$ OR $v^2 = 13.8$ (v =) 3.7 (m/s)	accept answers in terms of GPE lost = KE gained, whatever candidate chooses for mass can be implied from calculation reject if contradicted by another irrelevant formula and no further working seen allow if 13.8 seen allow 3.72, 3.715...	4
(c)	any one from: MP1. Mars has a smaller mass; MP2. Mars has a lower density; MP3. Mars has a smaller (iron rich) core;	allow RA allow Mars is less massive	1

Q18.

Question number	Answer	Notes	Marks
(a)	straight arrow drawn in line with the comet pointing from comet towards the star;	judge straightness by eye	1
(b)	use of weight = mass × g; substitution OR rearrangement; evaluation; unit; e.g. $W = m \times g$ $4.4 \times 10^9 = 2.2 \times 10^{14} \times g$ OR $g = W / m$ (g =) 2.0×10^{-5} N/kg	seen or implied allow m/s^2	4
(c)	any three from: MP1. distance of comet from star increases; MP2. gravitational field strength decreases; MP3. mass of comet remains constant; MP4. (therefore) gravitational force decreases; MP5. direction of force changes (because comet's direction changes);	allow comet gets further from star allow mass decreases if suitably qualified	3

Q19.

Question number	Answer	Notes	Marks
(a) (i)	idea that extension is (directly) proportional to force or load; up to limit of proportionality;	condone 'mass' for force allow up to elastic limit	2
(ii)	line is not straight / eq; so, force and extension cannot be (directly) proportional;	allow line is curved	2
(b)	mechanical; elastic; kinetic / gravitational;	 allow elastic potential allow gravitational potential	3

(c)	drag force drawn horizontally left;
	
	drag force = thrust force;
	
	weight force drawn vertically downwards;
	
	weight force = lift force;
		judge by eye
		allow air resistance, friction
		judge by eye
		ignore force labels
		judge by eye
		allow gravitational force
		ignore gravity
		judge by eye
		ignore force labels
			4

		Total for Question = 11 marks	

Q20.

Question number	Answer	Notes	Marks
(a)	use of p = h × density × *g*; conversion of 57 cm into 0.57 m; evaluation; e.g. pressure difference = 57 × 820 × 10 pressure difference = 0.57 × 820 × 10 (pressure difference =) 4700 (Pa)	allow mark if formula on its own is seen in working allow use of *g* = 9.8, 9.81 470 000, 467 000, 467 400, 458 052, 458 519.4 etc. score 2 marks allow 4670, 4674, 4580.52, 4585.194 etc.	3
(b) (i)	substitution into W = m × g; evaluation; correct unit; e.g. W = 24 × 10 (W =) 240 newtons / N	no mark for formula on its own allow use of *g* = 9.8, 9.81 -1 for POT error e.g. incorrectly changing kg to g mark independently allow 235.2, 235.44	3
(ii)	substitution into p = F/A; evaluation; e.g. p = 240 / 1.2 (p =) 200 (Pa)	no mark for formula on its own allow ecf from (i)	2
(iii)	substitution into p = F/A; rearrangement; evaluation; e.g. 200 = F / 4.8 F = 200 × 4.8 (F =) 960 (N)	no mark for formula on its own allow ecf from (ii)	3

(c)	GPE of piston X = decrease; GPE of piston Y = increase; chemical energy of piston Y = no change; kinetic energy of piston Y = no change;	allow marks if the meaning is clear e.g. allow +, ↑ for increase etc.	4
		Total for Question = 15 marks	

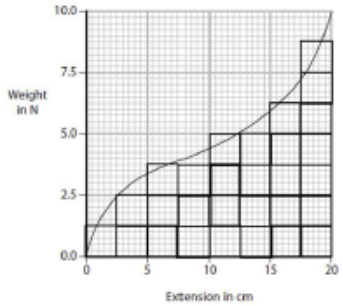
Q21.

Question number	Answer	Notes	Marks
	max. 2 marks for details of varying temperature MP1. suitable method of heating ball; MP2. thermometer used to measure temperature; **max. 2 marks for control variables** MP3. height ball is dropped from; MP4. bouncing surface; MP5. ball dropped from rest each time; **max. 2 mark for high-quality data** MP6. suitable method to increase/give good accuracy of bounce height measurement; MP7. at least five different temperatures tested; MP8. repeats and average;	any mark can be given from labelled diagram e.g. water bath, oven, freezer, heating water in beaker allow temperature sensor and data logger ignore "same ball" allow idea of no force being used to drop ball e.g. viewing at eye level, recording with camera and viewing at slow motion can be inferred from method	6

Q22.

Question number	Answer	Notes	Marks
(a)	one mark for each correct row;;; Energy store in magnet B / Increases / Decreases / Stays the same gravitational / ✗ / ✓ / ✗ magnetic / ✓ / ✗ / ✗ kinetic / ✗ / ✗ / ✓		3
(b)	downward arrow labelled "weight"; arrow same length as upward force arrow;	ignore gravity allow gravitational force, gravitational pull ignore arrows associated with magnet A judge by eye	2
(c)	any five from: MP1. caliper (to measure distance); MP2. balance (to check mass is 10g); MP3. use of set square to ensure vertical distance; MP4. independent variable identified as the mass added; MP5. dependent variable identified as the distance; MP6. repeat readings and find mean (average); MP7. plot graph of results; MP8. (identify and) remove / ignore anomalies;	allow any marking point if clear from diagram allow ruler, measuring tape allow scales	5
(d)	any three from: MP1. idea of magnet C providing a downward force on magnet B; MP2. idea that total downward force on magnet B is greater (than before); MP3. (creating) resultant downward force on magnet B; MP4. idea that (upward) force of magnet A on magnet B increases (when B moves down the shaft); MP5. (because) idea that decreased distance gives stronger magnetic field (between A and B);	ignore any references to magnets having different strengths allow "B is repelled by C" / eq allow idea that total downward force greater than upward force allow A repels B more strongly	3 Exp
			Total for question 4 = 13 marks

Q23.

Question number	Answer	Notes	Marks
(a)	determine stretched/original length; with a ruler / tape measure; extension = stretched length - original length/12(cm);	set unstretched length to zero (on) ruler reading on ruler is extension	3
(b) (i)	line is not straight / line is curved; (therefore) weight/force and extension are not proportional to each other;	allow gradient is not constant	2
(ii)	evidence of using a reasonable method of estimating an area; evaluation of the area of one shape; correct evaluation of area without factoring cm to m; correct final evaluation; e.g. counting squares approach used 1 medium square = (1.25 × 2.5 =) 3.125 total area = 29 squares × 3.125 = 91 increase in energy = (91/100 =) 0.91 (J)	e.g. counting squares, splitting into rectangles, approximating to a triangle etc. medium square = 0.03125 (J) large square = 0.125 (J) allow 85-100 allow 0.85-1.00 (J)  	4
		Total for Question = 9 marks	

Q24.

Question number	Answer	Notes	Marks
(a)	substitution into $v^2 = u^2 + 2as$; rearrangement; evaluation; e.g. $0^2 = u^2 + (2 \times -1.8 \times 92\,000)$ $u = \sqrt{3.6 \times 92000}$ (initial speed =) 580 (m/s)	allow answers in terms of conservation of energy for full marks ignore units condone poor handling of minus signs allow 575.(499...) (m/s) answer of 331 200 gains 2 marks POT error on distance will give 18.2 (m/s) for 2 marks	3

(b)	(i)	particles collide with walls; (collisions result in) force on walls; force over area gives pressure;	ignore collisions between particles allow momentum arguments allow p = F / A	3
	(ii)	substitution into $p_1/T_1 = p_2/T_2$; rearrangement; evaluation; e.g. $8.2/1200 = p_2/1600$ $p_2 = (1600 \times 8.2/1200)$ (p_2 =) 11 (kPa)	allow pressure in kPa or Pa allow 10.9... (kPa)	3
	(iii)	any three from: particles have more kinetic energy; particles collide with walls more **frequently**; idea that particles collide with walls with more force / 'harder'; (average) force increases;	 allow particles move faster/eq.	3
	(iv)	any three from: MP1. idea that higher pressure means higher speed; MP2. Tvashtar particles have more (initial) KE; MP3. particles from both chambers experience the same deceleration; MP4. (higher speed with same deceleration) takes longer to reach 0 m/s; MP5. relevant quantitative argument based on motion formulae; MP6. Tvashtar particles have more GPE (at max. height);	 allow Tvashtar particles have higher speed / RA allow Tvashtar particles take longer to reach max. height / RA	3
			Total for Question = 15 marks	

Q25.

Question number	Answer	Notes	Marks
(a) (i)	weight = mass × gravitational field strength;	allow rearrangements and standard symbols e.g. W = m × g ignore 'gravity' for g	1
(ii)	substitution or rearrangement; evaluation; e.g. 520 = mass × 10 OR mass = W / g (mass =) 52 (kg)	 allow g = 9.8, 9.81 allow 53.1, 53.0, 53	2
(b) (i)	evidence of counting squares to find area; number of squares in range 37-42; evaluation of area of one square; evaluation of total area; e.g. dots seen in each square in diagram number of squares = 39 area of one square = (2 × 2) = 4 cm² total area = (4 × 39) = 156 cm²	allow attempt to find area by splitting into rectangles / triangles allow if 2 × 2 seen in working allow ecf from incorrect number of squares allow 148-168	4
(ii)	pressure = force / area;	allow standard symbols and rearrangements e.g. p = F / A	1
(iii)	dimensionally correct substitution; evidence of doubling area or halving pressure to account for both feet; evaluation with matching unit; e.g. (pressure =) 520 / 156 area = 156 × 2 OR pressure = 3.2 ÷ 2 (pressure =) 1.7 N/cm²	allow ecf from (b)(i) allow N/cm², N/m² or Pa if no marks awarded for calculation allow 1 mark if valid unit for pressure given allow 1.5-1.8 N/cm² allow 15 000-18 000 N/m²	3

Q26.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a)</td><td>one mark for each correct row;;;;
<table><tr><th rowspan="2">Type of motion</th><th colspan="4">Graph</th></tr><tr><th>P</th><th>Q</th><th>R</th><th>S</th></tr><tr><td>constant acceleration</td><td></td><td></td><td>✓</td><td></td></tr><tr><td>increasing acceleration</td><td></td><td></td><td></td><td>✓</td></tr><tr><td>moving at constant velocity</td><td>✓</td><td></td><td></td><td></td></tr><tr><td>stationary</td><td></td><td>✓</td><td></td><td></td></tr></table>reject mark for row if more than one tick seen</td><td></td><td>4</td></tr>
<tr><td>(b)</td><td>area (under the line) / eq;</td><td></td><td>1</td></tr>
<tr><td colspan="4">Total for Question = 5 marks</td></tr>
</table>

Q27.

Question number	Answer	Notes	Marks
(a)	north pole labelled on magnet Y; lines drawn straight and vertical between magnets; lines are equally spaced with arrows pointing upwards;	ignore curved lines at the edges of the magnets	3
(b) (i)	any two from: MP1. iron is (a) magnetic (material); MP2. iron ball becomes a magnet / becomes magnetised (N pole at top); MP3. iron ball is attracted to the magnet;		2
(ii)	downward arrow drawn shorter than magnetic force arrow;	ignore starting point of arrow, judge length and direction only	1
(iii)	weight = mass × gravitational field strength;	allow standard symbols and rearrangements e.g. m = W / *g*	1
(iv)	calculation of weight; dimensionally correct substitution into weight formula; rearrangement; evaluation; e.g. weight = (165 – 124 =) 41 (mN) 0.041 = mass × 10 (mass =) 0.041 / 10 (mass =) 0.0041 (kg)	ECF if incorrect weight or 165, 124, 289 used as the weight allow g=9.8, 9.81 -1 for POT error provided 10 (N/kg) is used somewhere 0.0165, 0.0124, 4.1 gets 3 marks max 16.5, 12.4 gets 2 marks max	4
(v)	any two from: MP1. weight (of the iron ball) stays the same; MP2. magnetic force increases; MP3. magnetic field strength increases;	allow greater attraction from magnet	2

Q28.

Question number	Answer	Notes	Marks
(a)	any two from: MP1. height is <u>independent variable</u>; MP2. at least five different heights tested; MP3. range is <u>dependent variable</u>; with any two from: MP4. one control variable named; MP5. second control variable named; MP6. idea of repeating process at each height to find mean; AND: MP7. ruler used to measure height / range; MP8. suitable method to see where ball lands;	 e.g. launch speed/launch force, angle of launch, same ball allow repeating process at each height to identify anomalies allow tape measure condone metre stick e.g. record video (and playback in slow motion) cover ball in paint, material on floor to show landing point etc.	6

(b)	(i)	smooth curve within one small square of data points;	ignore extrapolation of curve beyond the points take care the curve is not dot to dot straight lines	1
	(ii)	height reading consistent with curve of best fit;	allow 0.15-0.25 (m) allow ECF from (b)(i)	1
	(iii)	idea that (both) variables are continuous;	allow results/data are continuous	1
	(iv)	pair of readings taken from graph; substitution into given formula; rearrangement; evaluation to at least 1 decimal place; e.g. range = 1.92m when height = 2.0m $1.92 = \text{launch speed} \times \sqrt{\frac{2.0}{5}}$ launch speed = $1.92 / \sqrt{0.4}$ (launch speed =) 3.0 (m/s)	allow data points or readings taken from candidate's curve allow ECF from (b)(i) and (b)(ii) 3 marks max. for reverse argument e.g. using speed of 3 m/s to calculate height or range allow range 2.9-3.1 (m/s) unless ECF from (b)(i)	4
			Total for Question = 13 marks	

Q29.

Question number		Answer	Notes	Marks
(a)		zero/0 (N);		1
(b)	(i)	pressure = depth × density × gravitational field strength;	allow use of standard symbols e.g. $p = h \times \rho \times g$ allow 'd' for 'h' reject 'gravity' for 'g' in formula	1
	(ii)	substitution; evaluation; e.g. pressure = depth × density × gravitational field strength pressure = 0.041 × 1000 × 10 pressure = 410 (Pa)	-1 POT error allow use of 9.8(1) for 'g' giving 401.8...	2
	(iii)	pressure = force ÷ area;	allow use of standard symbols e.g.P = F ÷ A	1
	(iv)	substitution or re-arrangement; evaluation; e.g. pressure = force ÷ area 400 = force ÷ 0.0017 force = 400 × 0.0017 = 0.68 (N)	substitution and rearrangement in either order allow correctly rounded values e.g. 0.697 allow use of candidate's unrounded value even if not approx 400	2
	(v)	upwards force greater than weight of cube; **resultant** force upwards;	allow idea of ice being less dense than water for 1 mark.	2
			(Total for Question = 9 marks)	

Q30.

Question number	Answer	Additional guidance	Mark
(a)	• Downward arrow labelled 'weight' (1) • Upward arrow labelled 'reaction' (1) • Both arrows of approximately equal length and drawn in line with ball (1)	ignore 'gravity' allow 'gravitational force', 'force due to gravity' allow 'normal reaction force', 'normal contact force'	3

Question number	Answer	Additional guidance	Mark
(b)(i)	0.51 (seconds)	allow value in range 0.50–0.52 (seconds)	1

Question number	Answer	Mark
(b)(ii)	An explanation that makes reference to the following linked points: • gradient is equal to the {speed/velocity} of the ball (1) • gradient is increasing over time (1) • (therefore) the {speed/velocity} is increasing with time (1)	3