VOLAIR EDUCATION

Physics Unit 3 and 4 Practice Exam 1

Answers

Multiple Choice

Question	Answer	Explanation
1	A	Since the block is moving at a constant velocity, the sum of the forces on it must be zero.
2	C	$v = \frac{72}{3.6} = 20\ m\ s^{-1}$ $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{20^2}{(150)(9.81)}\right) = 15.2°$
3	A	$R = \frac{u^2 \sin 2\theta}{g} = \frac{13.8^2 \sin(2)(32)}{9.81} = 17.4\ m$
4	D	$a = 9.81 \tan 7 = 1.20\ m\ s^{-1}$
5	C	The downward arrow represents the gravitational force acting vertically downwards on the mass. The angled arrow represents the tension in the string, which is tilted because the train is accelerating forward.
6	D	$\frac{1}{2}kx^{\cancel{2}} = mg\cancel{h}, where\ x = h$ $\left(\frac{1}{2}\right)k(0.589) = (1.5)(9.81)$ $k = 50.0\ N\ m^{-1}$
7	D	As before this point the mass would either be increasing its velocity or decreasing its velocity.
8	D	$E = \frac{V}{d}$ $V = Ed = (2000)(0.25) = 500\ V$
9	A	$W = Vq = (500)(1.6 \times 10^{-19}) = 8 \times 10^{-17}\ J$ $KE = \frac{1}{2}mv^2$ $v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{(2)(8 \times 10^{-17})}{9.11 \times 10^{-31}}}$ $v = 1.33 \times 10^{7} ms^{-1}$

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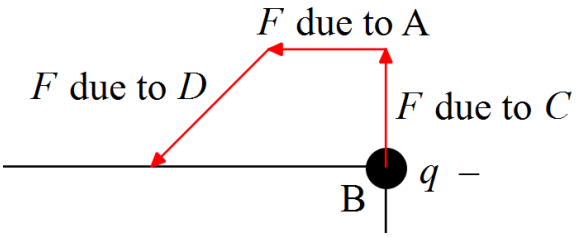
Question	Answer	Explanation
10	C	 Note the vertical component of the F on the charge at B due to the charge at D must cancel the F on the charge at B due to the charge at C. The direction of the force indicates that the charge at D must be positive.
11	B	Since $EMF = \frac{-N\Delta\phi}{\Delta t}$ halving the period will half the EMF and double the period.
12	D	$I = \frac{P}{V} = \frac{1}{0.4} = 2.5\ A$
13	A	80 photovoltaic cells in series. In series the current remains the same but the voltage is added together, 80 × 0.4 = 32 V
14	A	The spaceship will only contract in the direction of motion.
15	B	In special relativity, a clock that is observed to the moving will tick slower in the frame of reference of the observer. In the Earth's frame, a GPS satellite is moving at a few km/s, so its onboard clock runs slow as seen by observers on Earth. To keep the satellite time aligned with Earth time (as seen from Earth), you pre-offset the satellite clock to tick a bit faster.
16	A	The third exited state corresponds with n = 4. The longest wavelength corresponds to the lowest energy photon emitted.
17	B	Using $n = \frac{Path\ Difference}{\lambda} - \frac{1}{2}$ where n must be a whole number for interference to be destructive: $n = \frac{866.5 - 800}{1.4} - \frac{1}{2} = 47$

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Question	Answer	Explanation
18	B	There is a hyperbolic (inverse) relationship between E_k and λ.
19	C	Precision means the measurements are close to each other. Here, all readings are tightly clustered between 24.0 cm and 24.2 cm, so the results are precise. Accuracy means the measurements are close to the true value (25.0 cm). These readings are all about 0.8–1.0 cm too short, so they are not accurate.
20	C	Random error causes measurements to fluctuate unpredictably above or below the true value (e.g., due to small environmental changes, human reaction time, or reading uncertainty). Taking multiple measurements and averaging them reduces the effect of these unpredictable variations because the random positive and negative deviations tend to cancel out. Calibrating equipment (A) reduces systematic error, not random error. Using a different variable (B) doesn't inherently reduce error. Averaging systematic errors (D) doesn't help — systematic errors are consistent biases and don't cancel out with averaging.

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Short Answer

Question		Answer
1	a.	• **1 mark** $a = \frac{F}{m} = \frac{1.88}{1.26+3}$ • **1 mark** $a = 0.441\ m\ s^{-2}$
	b.	• **1 mark** $F = ma = (3)(0.441)$ • **1 mark** $F = 1.32\ N$ • **1 mark** Direction: East Note: The mass of B is used as the force on A due to B is the reaction force of the force on B due to A.
2	a.	• $v^2 = u^2 + 2as$ • **1 mark** $0 = (13\sin 30)^2 + (2)(-9.81)s$ • **1 mark** $s = 2.15\ m$ $s = 2.15 + 1.65$ • **1 mark** $s = 3.80\ m$
	b.	• **1 mark** $v_H = 13\cos 30 = 11.26\ m\ s^{-1}$ $v^2 = u^2 + 2as$ $v^2 = 0^2 + (2)(9.81)(3.80)$ • **1 mark** $v = 8.64\ m\ s^{-1}$ $v = \sqrt{8.64^2 + 11.26^2}$ • **1 mark** $v = 14.2\ m\ s^{-1}$

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<table>
<tr><th colspan="2">Question</th><th>Answer</th></tr>
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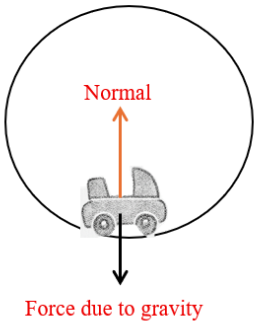
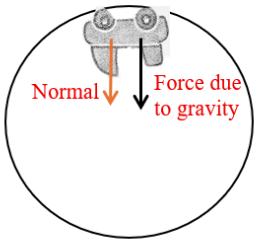
<tr><td>
</td><td>
</td></tr>
</table>
1 mark for each correct diagram
</td></tr>
<tr><td>b.</td><td>

$\frac{mv^2}{r} = mg + N$
When N = 0:
$\frac{\cancel{m}v^2}{r} = \cancel{m}g$
$v = \sqrt{rg}$
1 mark $v = \sqrt{(6)(9.8)}$
1 mark $v = 7.67\ ms^{-1}$

</td></tr>
<tr><td>c.</td><td>

$\cancel{m}g\Delta h = \frac{1}{2}\cancel{m}v^2$
1 mark $v = \sqrt{2g\Delta h} = \sqrt{(2)(9.81)(13)}$
1 mark $v = 15.97\ ms^{-1}$
1 mark Since 15.97>7.67 the occupants will experience a normal force towards the centre of the circle.

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Question		Answer
4	a.	• $T^2 = \frac{4\pi^2 r^3}{GM}$ • $M = \frac{4\pi^2 r^3}{GT^2}$ • **1 mark** $M = \frac{(4\pi^2)(4.2 \times 10^9)^3}{(6.67 \times 10^{-11})(6 \times 24 \times 60^2)^2}$ • $M = 1.63 \times 10^{29}$ kg
	b.	• $F = \frac{Gm_1m_2}{r^2}$ • **1 mark** $F = \frac{(6.67 \times 10^{-11})(3.72 \times 10^{24})(1.63 \times 10^{29})}{(4.2 \times 10^9)^2}$ • **1 mark** $F = 2.29 \times 10^{24}$ N
	c.	• $g = \frac{GM}{r^2}$ • **1 mark** $r = \sqrt{\frac{(6.67 \times 10^{-11})(3.70 \times 10^{24})}{7.62}}$ • **1 mark** $r = 5.71 \times 10^6$ m
	d.	• **1 mark** A geostationary satellite is a satellite that has an orbit that appears fixed in one place relative to a point on the planet it is orbiting.
5	a.	• **1 mark** Increase
	b.	• $F = qvB$ • **1 mark** $F = (1.6 \times 10^{-19})(4\,000)(5.39 \times 10^{-2})$ • **1 mark** $F = 3.45 \times 10^{-17}$ N
6		• $F = \frac{kq_1q_2}{r^2}$ • $q_1 = \frac{(F)(r^2)}{kq_2}$ • **1 mark** $q_1 = \frac{(1.7 \times 10^{-10})(2 \times 10^{-9})^2}{(8.99 \times 10^9)(1.6 \times 10^{-19})}$ • **1 mark** $q_1 = -4.73 \times 10^{-19}$ C • **1 mark** for labeling as a negative charge

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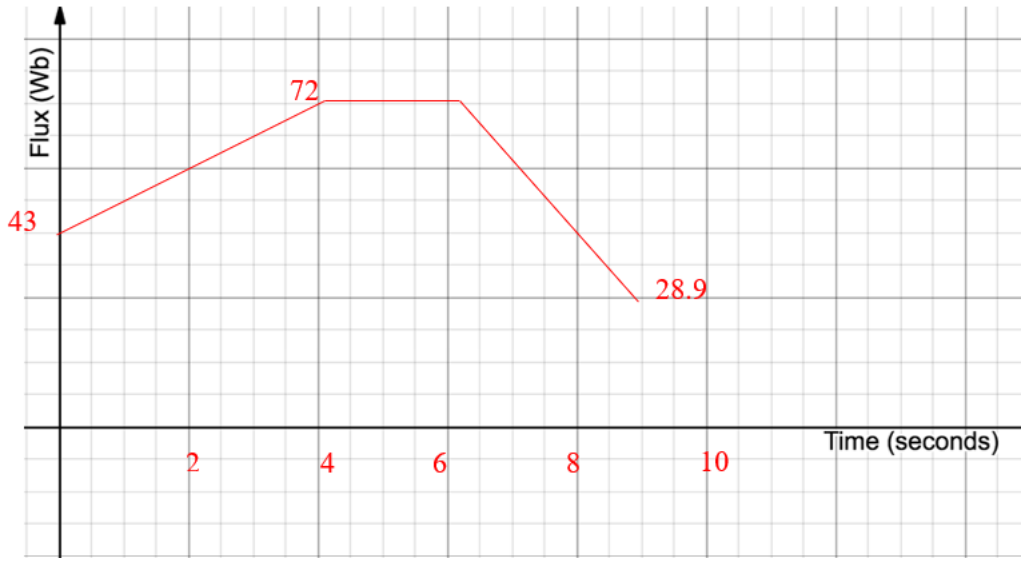
Question		Answer

7	a.	• Clockwise (C)
		• **1 mark** The direction of current is Z to Y (or X to W).
		• **1 mark** Using the right hand rule:
		  ○ Thumb point Z to Y
		  ○ Fingers point N to S
		• **1 mark** Palm is facing down, showing force on ZY is down causing a clockwise motion.

	b.	• **1 mark** A split ring commutator will reverse the direction of the current in the armature every half turn. • **1 mark** This ensures a constant direction of the torque.
	c.	• **1 mark** The torque of the motor is given by $F = 2nILB$ therefore $F \propto n$. • **1 mark** Therefore, an increase in the number of loops will result in a proportional increase in the torque of the motor.
8	a.	 • **1 mark** Correct start point, end point and gradient of the first line • **1 mark** Correct timing for each event • **1 mark** Correct start point, end point and gradient of the final line

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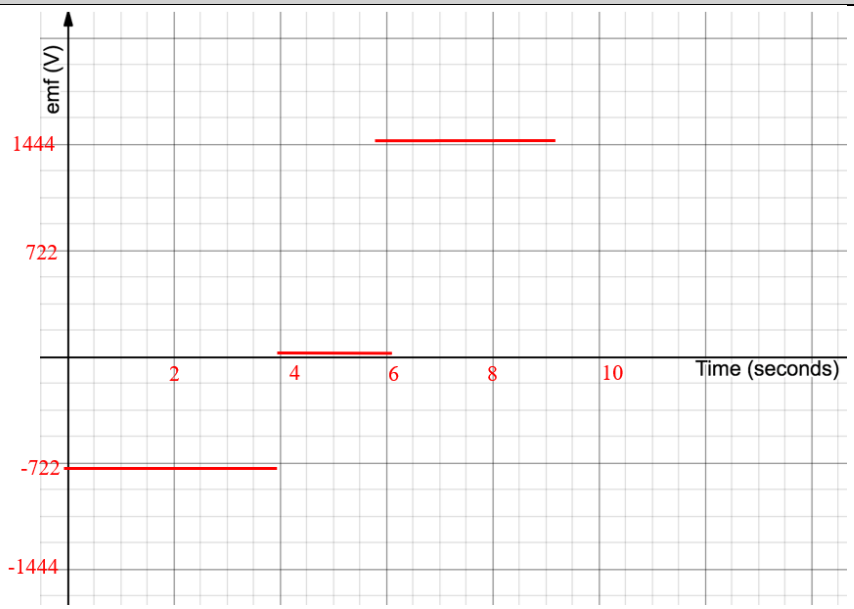
Question		Answer
8	b.	 • **1 mark** Correct start position of the first line • **1 mark** Correct timing for each event (including the 2 seconds of no emf) • **1 mark** Correct position of the final line
	c.	• **1 mark** DCBA
	d.	• **1 mark** No emf will be induced • **1 mark** This is because there is no change in the magnetic flux over time, thus there will be no emf induced.
9	a.	• **1 mark** $I = \frac{P}{V} = \frac{60.08}{120.16}$ • $I = 0.5\ A$
	b.	• $I_{transmission\ lines} = \frac{0.5}{5} = 0.1\ A$ • **1 mark** $V_{drop} = IR = (0.1)(8) = 0.8\ V$ • **1 mark** $V_{at\ step-down\ transformer} = 600.8 - 0.8 = 600V$ • **1 mark** $V_{Light\ globe} = \frac{600}{5} = 120\ V$
	c.	• **1 mark** $P_{loss} = I^2R = (0.1)^2(8) = 0.08\ W$

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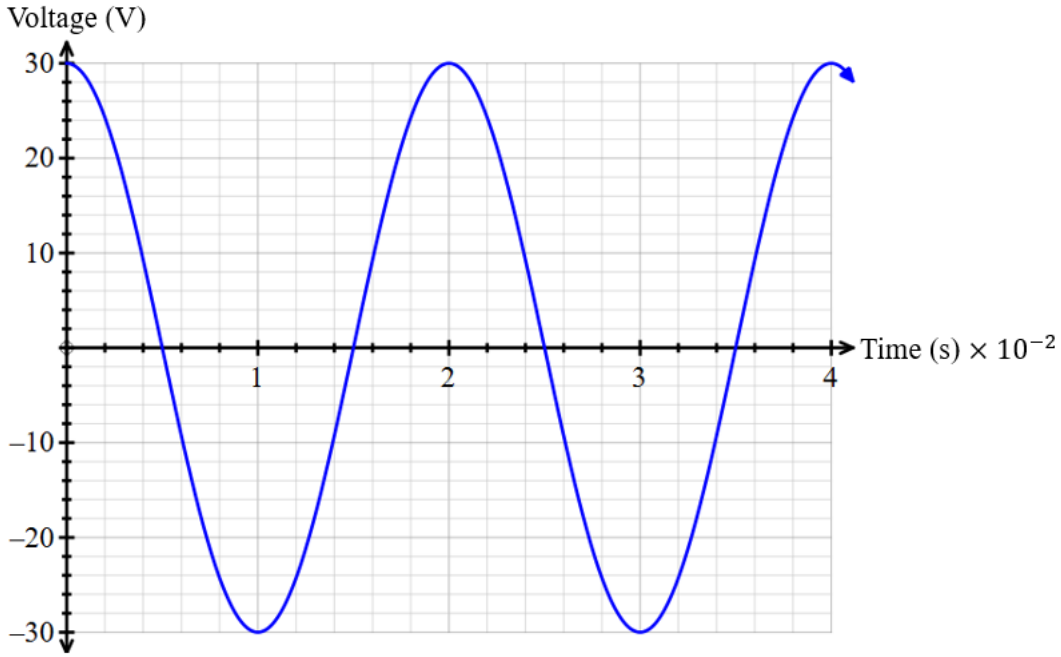
Question		Answer
10	a.	• **1 mark** Y to Z
	b.	 • **1 mark** Start from maximum voltage (30V) • **1 mark** Shows two waves • **1 mark** Correct peak (30 V) correct time scale (0.02 s each cycle) Note Graph can be inverted
	c.	• **1 mark** $V_{RMS} = \frac{V_{Peak}}{\sqrt{2}} = \frac{30}{\sqrt{2}}$ • **1 mark** $V_{RMS} = 21.2\ V$
11	a.	• **1 mark** $f = \frac{nv}{2L} = \frac{(4)(130)}{(2)(727\times10^{-3})}$ • **1 mark** $f = 358\ Hz$
	b.	• **1 mark** Since $f_n = nf_1$ any 'n' harmonic needs to be a multiple of the fundamental frequency which is 89.4 Hz. • **1 mark** Since 268.2 Hz is the third multiple of the fundamental frequency it can be formed, as the third harmonic.

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Question		Answer
12	a.	• **1 mark** The point A is point of minimum light intensity because the path difference is 1.5λ. • **1 mark** Resulting in destructive interference at that point
	b.	• **1 mark** $\Delta x = \frac{\lambda L}{d} = \frac{(400\times10^{-9})(1.75)}{0.5\times10^{-3}}$ • **1 mark** $\Delta x = 1.40 \times 10^{-3}\ m$
	c.	• **1 mark** The interference pattern observed (alternating bright and dark fringes) can only occur due to waves. • **1 mark** Hence the presence of an interference pattern is evidence that light behaves as a wave.
13	a.	• **1 mark** $E_k = \frac{hc}{\lambda} - \phi = \frac{(4.14\times10^{-15})(3\times10^{8})}{900\times10^{-9}} - 1.1$ • **1 mark** $E_k = 0.28\ eV$
	b.	• **1 mark** $E_k = \frac{hc}{\lambda} - \phi = \frac{(4.14\times10^{-15})(3\times10^{8})}{1200\times10^{-9}} - 1.1 = -0.065\ eV$ OR • **1 mark** $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3\times10^{8})}{1200\times10^{-9}} = 1.035\ eV$ • **1 mark** Since the energy of the photons (1.035 eV) is less than the work function (1.1 eV) no electrons will be liberated.
	c.	• **1 mark** Photons with a smaller wavelength have more energy. • **1 mark** If the power is kept the same there will be fewer photons per second. So fewer electrons will be ejected and the photocurrent will decrease *Other possible answers:* • **1 mark** Photons with a smaller wavelength have more energy. • **1 mark** More deeper electrons could be emitted. So more electrons will be emitted, so a greater photocurrent • **1 mark** Photons with a smaller wavelength have more energy • **1 mark** Less photons arrive but can liberate deeper electrons. Same number emitted, so the photocurrent remains constant

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Question		Answer
13	d.	Any of the following: • **1 mark** The existence of a threshold frequency (also known as cut off frequency). • **1 mark** The frequency of the wave is a measure of its energy. Light below this frequency does not have sufficient energy to liberate electrons. This occurs regardless of light intensity as light intensity is just a measure of the number of photons. OR • **1 mark** Negligible time delay of ejection of photons • **1 mark** The particle model explains this as when photons which have sufficient energy (above the threshold frequency) strike an electron, the energy is immediately transferred, it is a particle collision between a photon and an electron. OR • **1 mark** The independence of stopping voltage from intensity • **1 mark** The photons energy is a product of its frequency not intensity, as intensity is indicative of the number of photons. Therefore, increasing the intensity increases the number of photons hitting the cathode but the amount of energy transferred during photon electron collisions is constant thus the stopping voltage remains constant. OR • **1 mark** The maximum photocurrent is proportional to the intensity of light • **1 mark** Intensity of light is related to the number of photons that a source emits per second. If the light intensity doubles then the number of photons also doubles. One photon can only excite one electron, therefore if the number of photons are doubled then the number of photoelectrons being produced will also double.
14	a.	• Fourth excited state, n = 5 • Shortest = most energy, E5 → E1 • **1 mark** 10.44 – 4.66 = 5.78 eV • $E = \frac{hc}{\lambda}$ • **1 mark** $\lambda = \frac{hc}{E} = \frac{(4.14\times10^{-15})(3\times10^{8})}{5.78} = 215 \times 10^{-9}\ m$ • **1 mark** $215\ nm$

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Question		Answer
14	**b.**	• **1 mark** $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3\times10^{8})}{161\times10^{-9}} = 7.71\ eV$ • **1 mark** $7.71 - 10.44 = -2.73\ eV$
15	**a.**	• **1 mark** $p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{350\times10^{-9}} = 1.89 \times 10^{-27}\ kg\ ms^{-1}$
	b.	• $\Delta p = mv - \cancel{mu}$ • **2 marks** $(2)(1.89 \times 10^{-27})(60 \times 60 \times 24)(3.54 \times 10^{25}) = (5)v$ • **1 mark** $v = 2.32\ \times 10^{3}\ m\ s^{-1}$ • **1 mark** $1.16 \times 10^{3}\ m\ s^{-1}$ $(did\ not\ consider\ the\ momentum\ change\ is\ 2 \times p_{Photon})$
16	**a.**	• **1 mark** $t = t_0\gamma = (2.2)(1.25)$ • **1 mark** $t = 2.75\ \mu s$
	b.	• **1 mark** $L = \frac{L_0}{\gamma} = \frac{500}{1.25}$ • **1 mark** $L = 400\ m$
	c.	• **1 mark** $E = \gamma mc^2 = (1.25)(1.88 \times 10^{-28})(3 \times 10^{8})^2$ • **1 mark** $E = 2.115 \times 10^{-11}\ J$

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Question		Answer

17 **a.**

Classification	Variable
Independent variable	Time of collision (may also say amount of padding)
Dependent variable	Average force
Controlled variable	Any of the following (note environment, too vague): Mass of the dummy head – always 4.50 kg. Drop height – kept the same each time so the impact speed is constant. Force sensor type and calibration – same sensor for all trials. Surface under the padding – same material and condition each time. Method of dropping – same orientation and release method so the head impacts in the same way. Padding material type – only the amount of padding changes; the material remains the same.

- **1 mark** for each correct variable

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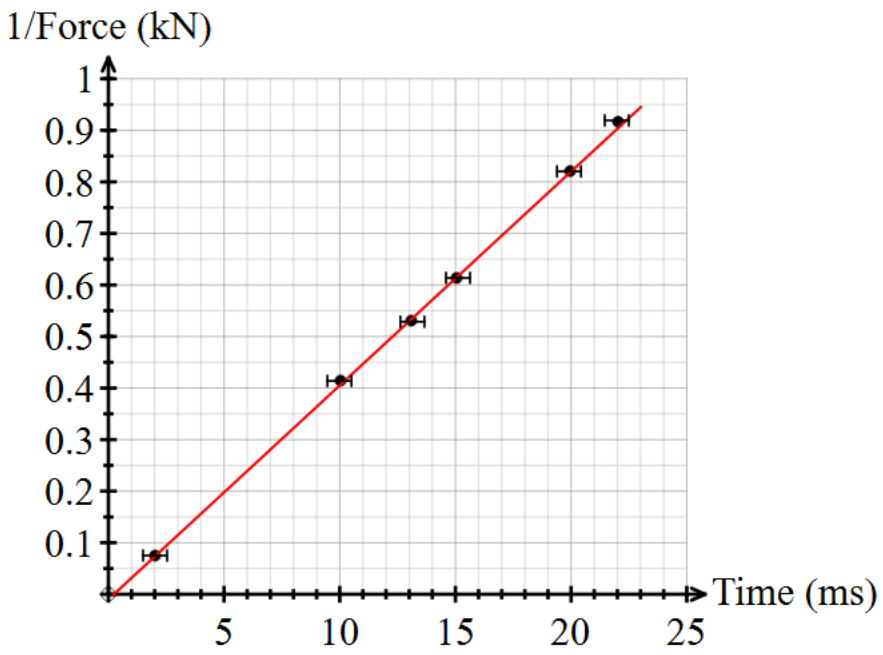
Question		Answer
17	b.	 • scale • 1 error bars • 1plotting • 1 Line of best fit
	c.	• **1 mark** $Use\ Gradient = \frac{Rise}{Run} = 0.0409 \pm 0.005$ • $Gradient = \frac{\frac{1}{F_{avg}}}{t} = \frac{1}{F_{avg}t} = \frac{1}{I}$ • **1 mark** $Gradient^{-1} = I = 0.0409^{-1}$ • **1 mark** $I = 24.4\ N\ s$

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