SCIENCE TEACHERS ASSOCIATION VICTORIA 2024

TRIAL EXAMINATION

SOLUTIONS BOOK

PHYSICS

UNITS 3 & 4

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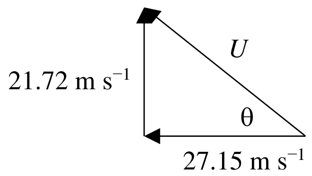
Section A – Multiple-choice questions

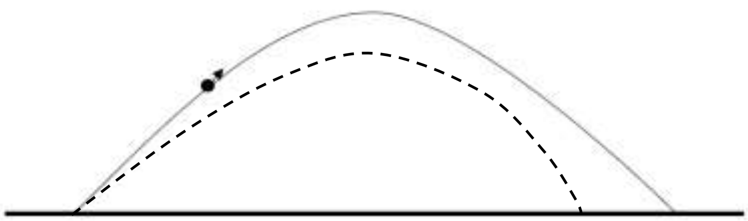
Q	Marks	Answer	Solution
1	**1**	**D**	The reading is 1.5 graduations below zero and each graduation is 10 kPa so the reading is −15 kPa. The uncertainty is half the smallest scale so ±5 kPa.
2	**1**	**B**	Newton's laws are valid in inertial frames of reference where an object is at rest or at constant velocity at speeds much lower than the speed of light.
3	**1**	**A**	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-0.9^2}} = 2.294$
4	**1**	**C**	Five wavelengths fit into the circumference of the atom in option C.
5	**1**	**D**	$P = I^2 \times R$ For P to be halved without changing R, I^2 must halve. I would therefore need to decrease by a factor of $\sqrt{2}$ = 1.41
6	**1**	**D**	Right hand curl rule gives the direction of the magnetic field at P due to the current in AB as out of the page and due to the current in CD as into the page. As P is closer to AB than CD, the magnetic field strength will be larger out of the page due to AB than that into the page due to CD. The net magnetic field will be out of the page.
7	**1**	**A**	Right hand curl rule gives the direction of the magnetic field at Q due to the current in AB as into the page and due to the current in CD as also into the page. As Q is 5 cm from each wire the strength of the fields will be the same and the field strength due to both wires will be X + X = 2X.
8	**1**	**A**	The right hand curl rule gives the right end of the solenoid as a south pole. This south pole will attract the north end of the bar magnet and will pull the bar magnet to the left.
9	**1**	**B**	The normal force acts at right angles to the track surface.
10	**1**	**A**	Distance travelled = area under a speed – time graph Area is a trapezium = ½ (1.5 + 2) × 1 = 1.75 m
11	**1**	**A**	acceleration = gradient of speed-time graph gradient = $\frac{\text{rise}}{\text{run}} = \frac{3}{6} = 0.5 \text{ m s}^{-2}$ [*any data points are ok to use*] F_{net} = m × a = 100 × 0.5 = 50 N

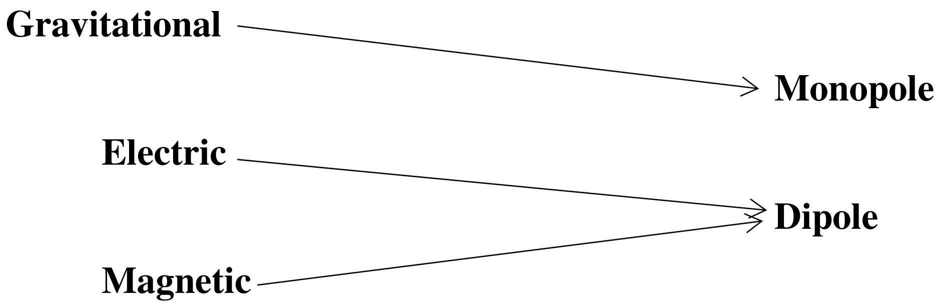
Q	Marks	Answer	Solution
12	**1**	**B**	$E_{\text{k max}} = hf - \phi$ h and ϕ are constants so as f decreases, $E_{\text{k max}}$ also decreases
13	**1**	**C**	$x = \frac{\lambda L}{d} = \frac{6.0 \times 10^{-7} \times 1.5}{2.0 \times 10^{-5}}$ = 0.045 m = 4.5 cm
14	**1**	**C**	$x = \frac{\lambda L}{d}$ so as brightness increases there is no change to x
15	**1**	**A**	Standing waves result from the interaction of a wave and its reflection.
16	**1**	**C**	The change in energy for arrows A & C = 8.8 – 4.9 = 3.9 eV. The arrow must point down to represent emission.
17	**1**	**C**	The wavelength is $^2/_3$ of the length of AB $\lambda = {}^2/_3 \times 1.2 = 0.8$ m
18	**1**	**D**	Solar energy is an example of electromagnetic waves. [*IR and UV are examples of electromagnetic waves*]
19	**1**	**B**	With the sun at 37°, a solar panel would work best inclined at 37° to the horizontal or 53° to the vertical. [*At the equator (0°), a solar panel would work best horizontal which is inclined at 0° to the horizontal or 90° to the vertical*]
20	**1**	**B**	Most current commercially available solar panels have an efficiency in the range of 15% to 20%. [*Efficiencies of possibly 25% might be available in 2025*]

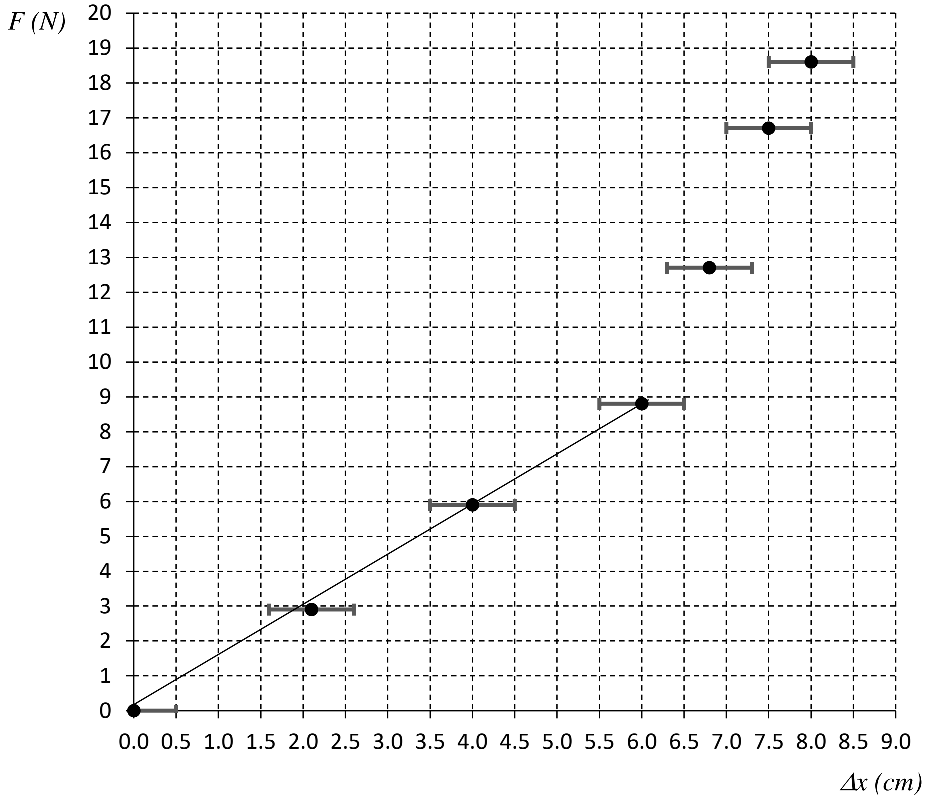
Section B

Q	Marks	Answer	Solution
1a	**2**	**5.4×10^3 J**	$E_k = ½ m v^2 = ½ \times 75 \times 12^2 = 5400$ J
b	**2**	**9.0×10^2 kg m s^{-1}**	$p = m v = 75 \times 12 = 900$ kg m s^{-1}
c	**3**	**3.6×10^2 N**	taking forwards as the positive direction: $u = 12, v = 0, s = 15, a = ?$ $v^2 = u^2 + 2 a s$ $0 = 12^2 + 2 a \times 15$ $a = \frac{-144}{30} = -4.8$ m s^{-2} $F_{braking} = m \times a = 75 \times 4.8 = 360$ N
d	**2**	Momentum has been transferred to the Earth. Kinetic energy has been transformed mainly into thermal energy (heat) by friction of the brakes on the wheels.	
e	**2**	Inelastic Monica's kinetic energy before braking is transformed into thermal energy (heat) and so kinetic energy before and after the interaction is not conserved **OR** kinetic energy before the interaction ≠ kinetic energy after the interaction	
2a	**3**	**2.2 N**	$F_{net} = \frac{m v^2}{r} = F_{tension} + F_{gravity}$ $F_{tension} = \frac{50 \times 10^{-3} \times 4.0^2}{0.30} - 50 \times 10^{-3} \times 9.8$ $F_{tension} = 2.67 - 0.49 = 2.18$ N
b	**4**	**5.3 m s^{-1}**	Energy at top = $E_{kinetic} + E_{gravitational\ potential}$ $= ½ \times 50 \times 10^{-3} \times 4^2 + 50 \times 10^{-3} \times 9.8 \times (2 \times 0.30)$ $= 0.4 + 0.294 = 0.694$ J Energy at bottom = 0.694 J = $E_{kinetic} = ½ m v^2$ $v = \sqrt{\frac{2 \times 0.694}{50 \times 10^{-3}}} = 5.269$ m s^{-1}
3a	**3**	$\frac{4 \pi^2 r}{T^2} = \frac{G M}{r^2}$ → $r = \sqrt[3]{\frac{G M T^2}{4 \pi^2}}$ $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times (24 \times 60 \times 60)^2}{4 \pi^2}} = 4.23 \times 10^7$ m 4.23×10^7 m = 4.23×10^4 km = 42 300 km	

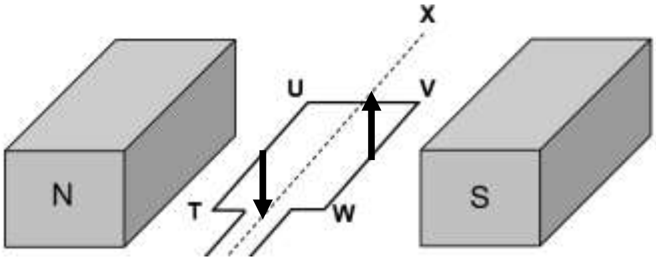
<table>
<tr><th>Q</th><th>Marks</th><th>Answer</th><th>Solution</th></tr>
<tr><td>b</td><td>2</td><td>3.1×10^3 m s^{-1}</td><td>$\frac{G\,M}{r^2} = \frac{v^2}{r} \rightarrow v = \sqrt{\frac{G\,M}{r}}$
$v = \sqrt{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{4.2 \times 10^7}}$ = 3081 m s^{-1}</td></tr>
<tr><td>4a</td><td>2</td><td>4.4 s</td><td>vertically to the top with upwards as positive:
$v = 0$, $s = 24$, $a = -9.8$, $t = ?$
$s = v\,t - ½\,a\,t^2$
$24 = 0 - ½ \times -9.8 \times t^2$
$t = \sqrt{\frac{2 \times 24}{9.8}}$ = 2.21 s
total time = 2 × 2.21 = 4.42 s</td></tr>
<tr><td>b</td><td>3</td><td>35 m s^{-1}</td><td>horizontally: $s = u\,t + ½\,a\,t^2$
$u = \frac{120}{4.42}$ = 27.15 m s^{-1}
vertically to the top: $s = ½\,(u + v)\,t$
$u = \frac{2 \times 24}{2.21}$ = 21.72 m s^{-1}
using Pythagoras, $U = \sqrt{27.15^2 + 21.72^2}$ =34.77 m s^{-1}
[conseq on answer to Q4a]</td></tr>
<tr><td>c</td><td>2</td><td>39°</td><td>

$\tan\theta = \frac{21.72}{27.15} \rightarrow \theta = 38.66°$ [conseq on parts of Q4b]</td></tr>
<tr><td>d</td><td>2</td><td colspan="2">
[lower maximum height and less range are essential, not symmetrical optional]</td></tr>
</table>

Q	Marks	Answer	Solution
5	**3**	**5.5×10^3 s**	$\frac{4\pi^2 r}{T^2} = \frac{GM}{r^2}$ → $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ $T = \sqrt{\frac{4\pi^2 (6.37 \times 10^6 + 354 \times 10^3)^3}{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}}$ = 5485 s
6	**1**	 [*arrows can point either way – simply a link, direction is not crucial*]	
7a	**3**	**66 N m^{-1}**	assume $E_{\text{k ball}} = E_{\text{s spring}}$ $\frac{1}{2} m v^2 = \frac{1}{2} k x^2$ $\frac{1}{2} \times 0.15 \times 4.2^2 = \frac{1}{2} \times k \times 0.20^2$ $k = \frac{0.15 \times 4.2^2}{0.2^2}$ = 66.15 N m^{-1}
b	**3**	**0.88 N**	assume $E_{\text{k ball}}$ = work done on the sticky surface = $F \times s$ $\frac{1}{2} \times 0.15 \times 4.2^2 = F_{\text{friction}} \times 1.5$ $F_{\text{friction}} = \frac{1.323}{1.5}$ = 0.88 N
8a	**2**	**2.9** **5.9** **8.8** **12.7** **16.7** **18.6**	$F = m \times 9.8$

Q	Marks	Answer	Solution
b	5	 [*both axes labelled and units filled in 2 marks, points plotted correctly 1 mark, error bars 1 mark, line of best fit to 6.0 cm 1 mark*]	
c	2	**approx 147 N m^{-1} (140 – 155 ok)**	k = gradient = $\frac{\text{rise}}{\text{run}} = \frac{8.8-0}{6.0\times10^{-2}-0}$ = 146.67 N m^{-1} [*two data values on the line of best fit must be used*]
d	2	**0.18 J (0.17 – 0.19 ok)**	E_s = area under the F v Δx graph up to 5.0 cm E_s = ½ × base × height = ½ × 5.0 × 10^{-2} × 7.3 = 0.18 J OR $E_s = \frac{1}{2} k x^2$ = ½ × 146.67 × (5.0 × 10^{-2})^2 = 0.18 J [*conseq on ans Q8c*]
9	5	**low voltage high current 240 V AC series parallel**	Inverters take {*low voltage/~~high voltage~~*}, and {*high current/~~low current~~*} signals from the PV panels and convert them into {~~*12 V$_{DC}$*~~/*240 V$_{AC}$*}, which is directly compatible with grid power. To increase output voltage solar cells are connected in {*series* / ~~*parallel*~~}. To increase output current solar cells are connected in {~~*series*~~ / *parallel*}.

<table>
<tr><th>Q</th><th>Marks</th><th>Answer</th><th>Solution</th></tr>
<tr><td>10</td><td>2</td><td>1.0×10^5 J</td><td>$12\% = \frac{\text{output power}}{\text{input power}}$
input power $= \frac{200}{0.12} = 1666.7$ J per second
$= 1666.7 \times 60$ J per minute $= 1.0 \times 10^5$ J (per minute)</td></tr>
<tr><td>11</td><td>4</td><td colspan="3">[Any two of the following examples for 2 marks each]
Quality of materials – well-made solar panels with quality materials will produce the highest electrical output.
Position relative to the sun – solar panels that are inclined towards the sun or that can track the sun as it moves across the sky will produce the highest output.
Cloud cover – clear skies with sunny conditions will produce the highest output.
Maintenance of panels – panels that are cleaned regularly and well maintained will produce the highest output.
Clear view – panels that have shadows cast on them by vegetation or other buildings will not produce the highest output.
Any other reasonable example and an explanation.</td></tr>
<tr><td>12a</td><td>2</td><td>C</td><td>The coil in the top diagram has maximum flux passing through it but a minimum $\frac{\Delta\Phi}{\Delta t}$ and so the emf is zero.</td></tr>
<tr><td>b</td><td>1</td><td colspan="2">The coil is being rotated at twice its previous rate of rotation.
OR The frequency of the coil’s rotation has doubled.</td></tr>
<tr><td>13a</td><td>2</td><td colspan="2">The 240 V measurement was made when no current was flowing in the extension lead. Once a current flows, 60 V is lost along the lead, leaving only 180 V at the barn socket.</td></tr>
<tr><td>b</td><td>2</td><td>20 Ω</td><td>$R = \frac{V}{I} = \frac{240 - 180}{3.0} = 20\ \Omega$</td></tr>
<tr><td>c</td><td>4</td><td>Toby</td><td>reason why Gary is incorrect: Adding another lead in parallel will effectively halve the lead resistance to 10 Ω but 30 V will still be lost leaving only 210 V at the barn.
OR
reason why Toby is correct: Using high turns ratio step-up and step-down transformers will reduce the current in the lead dramatically which will also reduce the voltage lost, giving close to 240 V at the barn.</td></tr>
</table>

Q	Marks	Answer	Solution
14a	**2**	 [*Right hand slap rule for each: current is T to U so F is down, current is V to W so F is up*]	
b	**2**	**1.0×10^{-2} T**	$F = n\,I\,l\,B$ $3.0 \times 10^{-4} = 1 \times 1.5 \times 2.0 \times 10^{-2} \times B$ $B = \frac{3.0 \times 10^{-4}}{3.0 \times 10^{-2}} = 1.0 \times 10^{-2}$ T or 0.01 T
c	**1**	**1.5×10^{-4} N**	half the length will have half the force
d	**2**	The battery supplies the current that produces the forces on the sides of the coil, enabling the motor to spin.	
15a	**2**	**1.2×10^{-10} m**	$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{5.5 \times 10^{-24}} = 1.205 \times 10^{-10}$ m
b	**3**	**10.3 keV**	$E = \frac{h\,c}{\lambda} = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{1.205 \times 10^{-10}} = 10\,307$ eV $E = 10.3$ keV [*conseq. on answer to Q15a*] [*OR could use E = p c and convert to keV which avoids the consequential*]
16a	**1**	**1 eV**	The work function is the absolute value of where the extended graph line intersects the *y*-axis. [*Not −1 eV*]
b	**1**	**≈ 2.4×10^{14} Hz**	The threshold frequency is the *x*-intercept which is approximately 2.4×10^{14} Hz.
c	**1**	**≈ 2.3 eV**	This is the *y* co-ordinate for the *x* value of 8.0×10^{14} Hz.
d	**2**	The value of the gradient is equal to Planck's constant. Its value should be approximately 4.14×10^{-15} eV s.	
e	**2**	This frequency is below the threshold frequency. This frequency light does not have enough energy to release photoelectrons.	

Q	Marks	Answer	Solution
17	**2**	**0.364 nm**	$\lambda = \frac{h}{m\,v} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 2.00 \times 10^{6}}$ $\lambda = 3.639 \times 10^{-10}$ m = 0.3639 nm
18	**2**	**6.9 × 10^{-7} m**	longest wavelength is the lowest energy this is from 6.7 eV → 4.9 eV = 1.8 eV $\lambda = \frac{h\,c}{E} = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^{8}}{1.8}$ $\lambda = 6.9 \times 10^{-7}$ m
19	**2**	The middle of the screen at point X is equidistant from both slits so the path difference is equal to zero. Constructive interference occurs here. [*It is called the central maximum*]	

END OF SUGGESTED SOLUTIONS