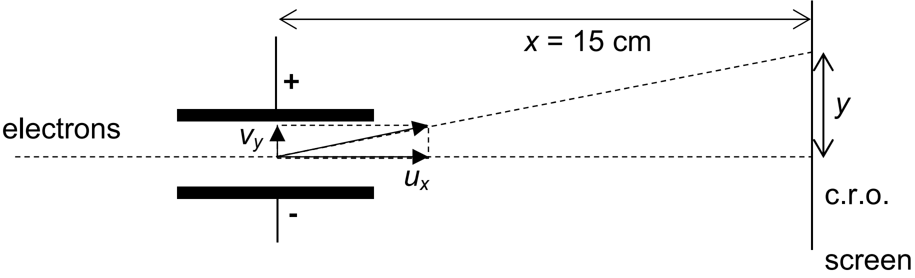
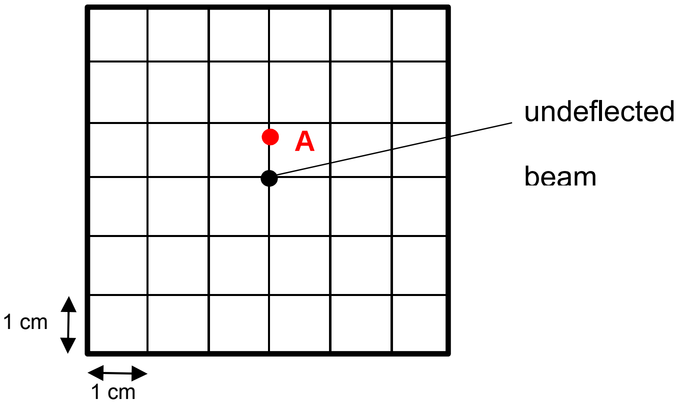
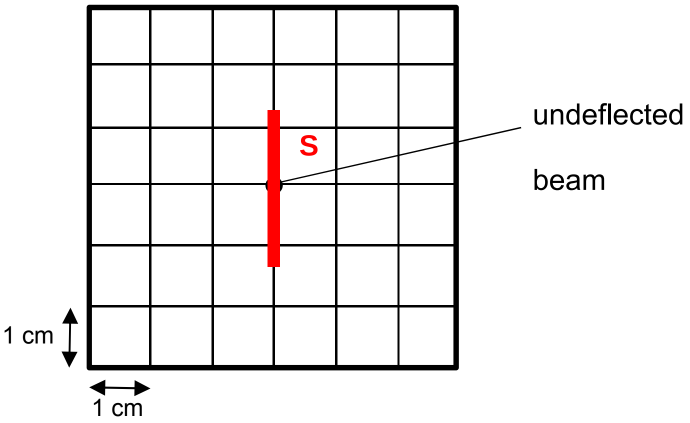
JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2013
H2 Physics Paper 2 solutions

Qn	Suggested solution	Remarks
1(a)	$T=2\pi\sqrt{\frac{l}{g}}\Rightarrow T^{2}=\frac{4\pi^{2}l}{g}\Rightarrow g=\frac{4\pi^{2}l}{T^{2}}$ ------(1) (2) $\frac{\Delta g}{g}=\frac{\Delta l}{l}+2\frac{\Delta T}{T}=\frac{0.1}{20.6}+2\frac{0.005}{0.910}=0.0158$ =1.6 % or 2 % (only accept 2 sig. fig. or 1 sig. fig.) Comments: Two common mistakes observed. First, *g* was not made the subject (1) and hence (2) was wrong. Second, the final answer was left as “1.58%”. A significant number of candidates mixed up absolute error and fractional/percentage error. Some candidates could have scored at least “[1] sub” but full substitutions of values were not presented.	**[1] sub** **[1] ans**
(b)	$g=\frac{4\pi^{2}l}{T^{2}}=\frac{4\pi^{2}(0.206)}{(0.91)^{2}}=9.821\text{ m s}^{-2}$ $\Delta g=(0.0158)(9.821)=0.2\text{ m s}^{-2}$ g = (9.8 ± 0.2) m s^{-2} Comments: Some candidates did not compute the value of *g* and erroneously assumed the value of 9.81 m s^{-1}. A significant number did not present Δg to 1 sf.	**[1]** *g* value 3-4 s.f. **[1]** Δg value 1 s.f. **[1]** *g* value 1 d.p.
2(a)	Taking moments about the elbow, Clockwise moment = anti-clockwise moment *T* cos 20° x 3 = (60 x 9) + (20 x 34) *T* = 433 N Comments: Many students failed to indicate the position at which moment is taken.	**[1] statement** **[1] sub**

Qn	**Suggested solution**	**Remarks**
(b)	$T_x = 433 \sin 20° = 148.1$ N $\sum F_x = 0$ $T_x = R_x =$ **148.1 N** $\sum F_y = 0$ $T_y = R_y + 60 + 20$ $R_y = 433 \cos 20° - 60 - 20 =$ **326.9 N** Resultant force R acting at elbow (pivot) $= \sqrt{R_x^2 + R_y^2} =$ **359 N** Angle $= \tan^{-1}(\frac{R_y}{R_x}) = \tan^{-1}(\frac{326.9}{148.1}) =$ **65.6° below the forearm** Comments: A significant number of students failed to consider the concept of translation equilibrium (Summation of horizontal forces / Summation of vertical forces = 0). Additionally, students do not consider the direction of the horizontal force resulting in the wrong angle direction even though the magnitude of the angel is correct.	**[1] value of R_x** **[1] value of R_y** **[1] value of R** **[1] correct direction**
3(a)(i)	$F = eE = e\left(\frac{V}{d}\right) = (1.6 \times 10^{-19})\left(\frac{80}{0.50 \times 10^{-2}}\right)$ $=$ **2.6×10^{-15} N** *Comments: Quite a number of students used F =qV.*	**[1] sub** **[1] ans**
(ii)	$a = \left(\frac{F}{m}\right) = \left(\frac{2.6 \times 10^{-15}}{9.11 \times 10^{-31}}\right) =$ **2.8×10^{15} m s^{-2}**	**[1] ans**
(iii)	Using $v = u + at \rightarrow v = at = (2.8 \times 10^{15})(6.5 \times 10^{-10})$ $=$ **1.8×10^{6} m s^{-1}** *Comments: Many students substituted the horizontal velocity for the initial vertical velocity.*	**[1] sub** **[1] ans**

Qn	Suggested solution	Remarks
(b)	Let y = deflection of electron beam on screen x = distance of plates to screen = 15 cm  Geometrically : $\frac{y}{x}=\frac{v_y}{u_x} \rightarrow \frac{y}{15}=\frac{1.8 \text{ x } 10^6}{3.1 \text{ x } 10^7}$ y = **<u>0.87 cm</u>**	**[1] sub** **[1] ans**
(c)	 	**[1] correct position with label**
(ii)	When $V_{\text{r.m.s.}}$ = 80 V, maximum deflection = ($\sqrt{2}$)(y) = **<u>1.2 cm</u>**  *Comments: Many students drew sinusoidal waves.*	**[1] value of maximum deflection** **[1] correct sketch with label**

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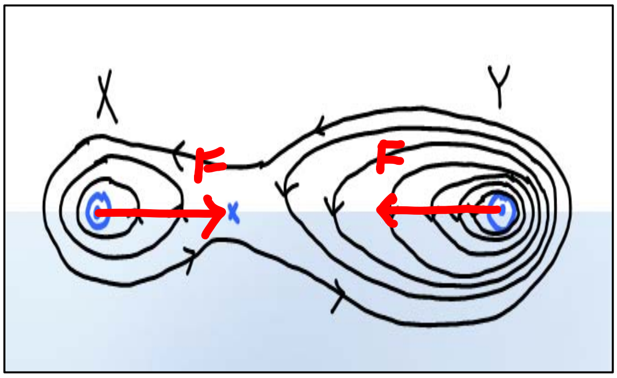
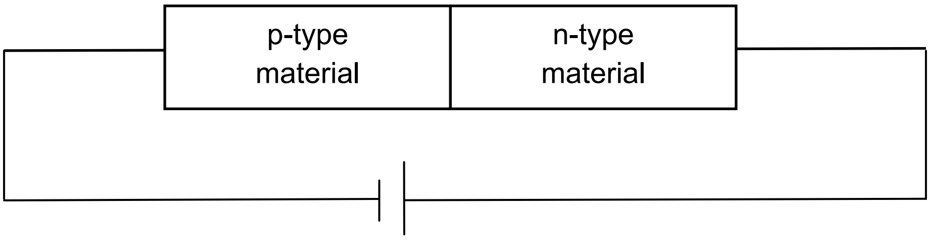
Qn	Suggested solution	Remarks
4(a)	The **tesla** is the magnetic flux density of a magnetic field in which the force per unit length per unit current acting on a straight conductor placed perpendicular to the magnetic field is one newton per metre per ampere. Comments: Very few provided answers that emphasise the significance of the ratio aspect i.e. force per unit length per unit current. Reference to "straight conductor placed perpendicular to the magnetic field" must be made. All units used (newton, metre and ampere) must be defined clearly and not written in symbols. NOTE: The following version is accepted for only this Prelims. The **tesla** is the magnetic flux density of a magnetic field in which the force per unit length acting on a straight conductor placed perpendicular to the magnetic field is one newton per metre when the current flowing through the conductor is one ampere.	**[1]** **[1] just for this Prelims; being the 2009 TYS solution provided to students**
(b)(i)	 Comments: Very few realised that (1) the position of the neutral point has shifted towards the left; (2) the spacing of field lines on the left and right side of X or Y are different.	**[1]** direction of magnetic field around both wires **[1]** spacing of magnetic field lines
(ii)1.	Magnetic flux density at Y = $(\frac{\mu_o I_x}{2\pi r})$	**[1]**
2.	Magnetic force = $B_1 I_2 L = (\frac{\mu_o I_x}{2\pi r}) I_y L$ Magnetic force per unit length = $(\frac{\mu_o I_x}{2\pi r}) I_y$	**[1]** for final expression

Qn	Suggested solution	Remarks
(iii)	$\text{Magnetic force per unit length} = (\frac{\mu_o I_x}{2\pi r})I_y = \frac{(4\pi \times 10^{-7})(100)}{2\pi(5)}(200) = 8.00 \times 10^{-4} \text{N m}^{-1}$ The magnitude of the force is small and hence the movement of the wires will be small compared to separation of wires. Comments: Many candidates did not realise they were expected to complete some calculations as part of their explanation even though values were provided in the question.	**[1]** ans **[1]** explanation
5(a)(i)	Vacuum **gap between STM probe and surface**. *Comments: Many students wrote "distance between…", but the distance is a measurement of the barrier, rather than the barrier itself.*	**[1]**
(ii)	The tunnelling current between the STM probe and the surface is sensitive to small variations of the width of the energy barrier, or vacuum gap. By moving the probe along the surface, the varying currents at each point is mapped out as varying depth/height of each point on the surface. By combining these points, an atomic-scale image of the surface is obtained. **OR** : By using a feedback mechanism, the probe is moved up or down to maintain constant current. The vertical motion is then plotted to obtain an atomic-scale image of the surface.	**[1]** **[1]**
(b)	Valence band is the highest occupied energy band whereas conduction band is the lowest unoccupied energy band. *Comments: Many students missed out the word "energy".*	**[1]** **[1]**
(c)(i)	In the p-type region, the majority charge carriers are holes and in the n-type region, the majority charge carriers are electrons. Diffusion of the mobile charge carriers occurs. Holes at the p-type region diffuse across the junction to the n-type region and electrons at the n-type region diffuse across the junction to the p-type region. As holes and electrons diffuse across in opposite directions, most of them meet and recombine near the junction. This resulted in the junction being depleted of mobile charge carriers hence forming the depletion region.	**[1]** **[1]** **[1]** **[1]**

Qn	Suggested solution	Remarks
(c)(ii)	 *Comments: A number of students did not draw a proper circuit for the battery.*	**[1]**
6(a)	The *half-life* of a radioactive nuclide is the average time taken for the activity to fall to half (its original value). **Points to note:** First there is the problem of the meaning of words such as isotopes, nuclide and nucleus. Here nucleus or its plural, nuclei, is usually required. Then there is the problem of what actually does halve in one half-life. The answers 'amount' or 'mass' or 'quantity' are not acceptable. Probably the simplest solution is to state that it is the activity which halves and include in the definition should be the comment that half-life is the *average* time for the activity to halve. Comments: Many students failed to include "average".	**[1]**
(b)(i)	The decrease in output from the detector results from an increase in the foil thickness. Hence, the separation of the rollers would decrease.	**[1]** **[1]**
(b)(ii)	$\frac{A_{end}}{A_{start}} = (\frac{1}{2})^{\frac{8.0}{14\times24}}$ $= 0.984 = \underline{0.98}$ (2 s.f.)	**[1]** working **[1]** ans

Qn	**Suggested solution**	**Remarks**
(b)(iii)	Advantage: 1. High activity which reduces inaccuracies/errors due to background radiation 2. Takes only a short time for activity to reach a safe level for disposal Disadvantage: 1. May cause the output from detector to vary (drop) rapidly without variation in the thickness of the aluminium sheet. 2. Frequent replacement of radioactive source	**[1]** for advantage **[1]** for disadvantage Any reasonable answer
(b)(iv)	γ-radiation could penetrate the aluminium foil with little loss in output (from the detector) and this loss may be too small to be detected easily or measured accurately.	**[1]**
7 (a) (i)	A parallel beam of γ-radiation is necessary to ensure that that all photons of the radiation **travel the same distance through the absorbers**. Accept : all photons will be directed towards the absorber & detector.	**[1]**
(ii)	Fig. 7.2 indicates that **as $C_x/C_o \rightarrow 0$, $x \rightarrow \infty$**, If candidate states the curve is an “exponential graph”, must still elaborate on the feature of the graph. implying that an infinitely thick absorber is needed to cause C_x/C_o to become zero. Hence, theoretically, complete shielding is not possible.	**[1]** observation from Fig. 7.2 **[1]** interpretation & conclusion

<table>
<tr><th>Qn</th><th>Suggested solution</th><th>Remarks</th></tr>
<tr><td>**(b)(i)**</td><td>
The straight negative-gradient line passing the origin on Fig. 7.3 implies:
$\ln(C_x/C_0) = -\mu x$, where , $-\mu$ = gradient
→ $C_x/C_0 = e^{-\mu x}$
→ $C_x = C_0 e^{-\mu x}$ (shown)

Alternative:
If equation $C_x = C_0 e^{-\mu x}$ is a possible relationship, → $\ln C_x = \ln C_0 - \mu x$.
→ $\ln C_x - \ln C_0 = -\mu x$
→ $\ln(C_x/C_0) = -\mu x$ ……….(1)
Since the graph in Fig. 8.3 is a straight line graph with passing through the origin, the equation of the line should be of the form $\ln(C_x/C_0) = -\mu x$.

As this is similar to equation (1), Fig. 8.3 shows a relationship of the form $C_x = C_0 e^{-\mu x}$

Comments: Students are able to do the mathematical conversion. However, they did not highlight the key point that the straight line passes through the origin.
</td><td>
[1] mention of “straight line” & “passing origin”

[1] mathematical manipulation.
accept
$\ln(C_x/C_0) = k x$
</td></tr>
<tr><td>**(ii)**</td><td>
From Fig. 7.3 for lead, $\mu = \frac{4.0}{9.0}$
$= \underline{\mathbf{0.444\ cm^{-1}}}$

Comments: It is very unfortunate that a handful of students read the wrong coordinates off the graph.
</td><td>
[1] sub

[1] ans (final value may vary slightly)
</td></tr>
<tr><td>**(c)(i)**</td><td>
$\mu_m = \frac{\mu}{\rho}$, → units of $\mu_m = \frac{\text{cm}^{-1}}{\text{g cm}^{-3}} = \mathbf{g^{-1}\ cm^{2}}$
</td><td>**[1]** ans</td></tr>
<tr><td>**(ii)**</td><td>
<table>
<tr><th>material</th><th>μ / cm^{-1}</th><th>ρ / g cm^{-3}</th><th>μ_m /</th></tr>
<tr><td>aluminium</td><td>0.095</td><td>2.70</td><td>0.035</td></tr>
<tr><td>tin</td><td>0.267</td><td>7.28</td><td>0.037</td></tr>
<tr><td>lead</td><td>**0.444**</td><td>11.3</td><td>**0.039**</td></tr>
</table>
</td><td>**[1]** value of μ_m & μ</td></tr>
<tr><td>**(d) (i)**</td><td>
From Fig. 7.2 (for lead), at x = 4.0 cm, $C_x/C_0 = 0.16$

Required thickness of concrete :
$x = -\frac{\ln(C_x/C_0)}{\mu} = -\frac{\ln(0.16)}{0.09}$
$= 20.4 \approx \underline{\mathbf{20\ cm}}$
</td><td>
[1] value from Fig. 8.2

[1] sub
[1] ans
</td></tr>
</table>

Qn	Suggested solution	Remarks
(ii)	1. Concrete may be used, in preference to lead, because it is a common building material that is readily available, costs less and easier to use for constructing the structure housing the radioactive sources. 2. Lead is toxic and relatively more difficult to maintain. 3. Concrete is structurally strong.	**[1]** **[1]** Any reasonable suggestions

8 (Planning)

Defining the problem (1 mark)

P1 ***x*** is the independent variable and ***efficiency, η,*** is the dependent variable or vary ***x*** and calculate η.[1]

Alternative dependent variable : **velocity *v* of arrow** / **kinetic energy of arrow** / **maximum potential energy of bow**.

Methods of data collection (4 marks)

M1 Diagram:

1. Bow properly clamped at the centre to a fixed object/mass
2. Labelled distance travelled by arrow to target
3. Position of centre of bow & target should be about same height [1]

M2 Force ***F*** is measured using a force meter / newton-meter / force gauge hooked to the centre of the string and pulled horizontally. [method of use is described or implied in diagram] [1]

M3 Distance ***x*** is measured with a metre rule [position & method of use is described or implied in diagram] [1]

M4 Determination of kinetic energy, ***K***, of arrow:

1. Measure distance *L* from front of bow to target using a **measuring tape** + time taken for arrow to travel, *t*, is measured using a **stopwatch**. [Details on marking the 2 points to aid in measurement are needed]. [1]
2. Mass of arrow, *m*, is measured using a **mass balance / electronic balance**. [1]
3. Velocity *v* of arrow is calculated using $v = \frac{L}{t}$

→ Kinetic energy of arrow, $K = \frac{1}{2}(m)\left(\frac{L}{t}\right)^2$ [1]

M5 Determination of stored potential energy, ***P***, of bow:

Plot a graph of *F* against *x*. For any given *x*, ***P* = area under the *F*-*x* graph**. [1]

[Do not accept answers based on Hooke's law]

Method of analysis (1 mark)

A Plot a graph of *lg* η against lg *x*. The equation is valid if a straight line is obtained.

Value of ***b* = gradient of graph**. [1]

Safety considerations (1 mark)

S Target should be made from soft material such as cork or styrofoam to reduce chances of arrows being deflected in other directions / arrows should be aimed only at target / ensure firing area cleared of people during experiment. [1]

Additional detail (2 marks) [1] per point, max [2]

D Relevant points might include [maximum : 2 marks]

1. Distance from bow to target, *L* > 25 m, to ensure the time of flight is adequately long to be measured on a stopwatch.
2. Carry out trial runs to determine the workable range of values of variables.
3. Perform experiment in an enclosed area with no wind / neglect measurements if wind is detected during experiment.

Do not award for vague computer methods.

12 marks can be scored in total

Comments:

Many marks could be scored by drawing a suitably labelled diagram but **any detail given in the question must be reproduced correctly on these diagrams**.

Candidates were expected to measure the distance *x* and the force *F* required and the mass of the arrow with suitable instruments such as metre rule, newtonmeter and balance. **Candidates should be encouraged to link a measurement to the appropriate measuring instrument**.

Most candidates quoted the correct formula for kinetic energy but hardly any candidates could determine potential energy. **The question stated that *x* is not proportional to *F* and so a way of determining potential energy was from the area under a *F-x* graph.** Many candidates needlessly quoted formulae using Young modulus or spring constant.

Unfamiliarity with a bow and arrow troubled some candidates and experiments using springs, elastic bands and ball bearings were seen with the latter being projected vertically. Sometimes a target was placed on the wrong side of the bow.

Candidates should be made aware that a well-drawn labelled diagram can score at least half the marks. Examples are *x* correctly drawn alongside a metre rule, *F* correctly shown with a newtonmeter, a target made from a suitable material and a suitable way of clamping the centre of the bow and a means of stopping it toppling over.

Determination of velocity was not as well carried out as expected. **Arrows were timed with stopwatches over unrealistically short distances** and although vertical firing was allowed suitable formulae for inclusion of the resulting data were rarely seen.

A rare misunderstanding of the question was exhibited by candidates who changed *x* while keeping *F* constant.