2018 SINGAPORE-CAMBRIDGE A LEVEL H2 PHYSICS P2 SUGGESTED ANSWER KEY (9749)

Written and Prepared by Mr Mitch Peh

Preface

Dear JC students in Singapore,
Hope you will find this A Level examination solution set useful for your revision.

The answers and comments to this solution set are personally crafted and written by Mr Mitch Peh, an experienced former MOE JC lecturer and tutor in Singapore. Currently, Mr Peh is a full time A Level private tutor, specialising in the teaching of A Level subjects: Physics, Chemistry, Mathematics and Economics at both H1 and H2 Levels. You can find the A Level solutions for the other subjects under the various subject tabs at www.jcpcme.com.

Mr Peh has a proven track record in helping his students achieve success for the A Levels and internal school examinations including promos, advancement tests to JC2, block tests, mid years and prelims. Most of Mr Peh's students achieve "A's and 'B's grades for the A Level examinations. During his stint teaching at St Andrew's Junior College, Mr Peh has helped his classes achieve 100% promotion to JC2 on multiple occasions, attain close to 100% "A"s for H1 Project Work, clinch accolades like "Most Improved Class Award" and "Best Performing Class of the Cohort" for many of the internal school examinations. Mr Peh also has former students who subsequently went on to pursue H3 subjects and enroll in prestigious university courses like Dentistry, Medicine and Law.

If you are interested to be coached by Mr Peh for your preparations towards the A Levels, these are 3 more reasons why you should join Mr Peh's classes:

1. **Lessons can be fully customised to your needs**
- You have the full autonomy to decide the subject(s), content and pace that you want to cover for each lesson, out of any of the 4 subjects: Physics, Chemistry, Mathematics or Economics.
- Mr Peh will help to analyse your weaknesses in each individual subject and provide personalised feedback and suggestions for improvement.

2. **Answers to your questions can be addressed outside of the classroom**
- If you face any difficulty or challenge doing any of your tutorial questions, simply take a screenshot with your phone and send it to Mr Peh via Whatsapp. Mr Peh will answer your questions in the earliest possible time when he is available.

3. **You only pay the price of 1 subject but enjoy premium coverage for all 4 subjects**.
- Mr Peh provides resources for all 4 subjects including summarised notes, compiled topical questions sourced from past year school prelim examinations, Practical guides for Chemistry & Physics, examination checklists, mock papers etc.
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Note that Mr Peh only takes in a limited number of students each year. You can find his lesson slots available under "Tuition Services" tab at www.jcpcme.com. For any further enquiries, you can directly whatsapp him at 9651 7737.

For the solution set below, if you find any discrepancies or you have any feedback or comments, please kindly direct them to Mr Peh through Whatsapp at 9651 7737.

The question paper has been omitted due to copyright reasons.

Analysis of 2018 H2 Physics Paper 2 and 3

- In general for A Level Physics, the topics that have not been tested in Paper 2 would be tested in Paper 3. Hence, after sitting for A Level Physics Paper 2, you should study smart and focus on revising the topics that have not been tested before your Paper 3.

Topics tested in 2018 Paper 2	Topics tested in 2018 Paper 3
• Forces • Work, Energy and Power • Circular Motion • Superposition • Current and Electricity • DC Circuit • Electric Field (Minimal) • Quantum Physics • Graphical Analysis Skills • Data Analysis Skills	• Kinematics • Dynamics • Gravitation • Electric Field • Electromagnetism • Electromagnetic Induction • Alternating Current • Quantum Physics • Nuclear Physics • Oscillation (Section B) • Thermal Physics and Ideal Gas (Section A)

- For A Level Physics, definition questions can take up quite a significant proportion of the marks and they are placed at the beginning of questions so you must remember to study them before the exams. It is also not necessarily true that the definitions tested in the previous year would not be repeated and tested again.
- In this 2018 Paper 2 and 3, 26 marks out of a possible 180 marks were set aside on definitions alone. Definitions tested include principle of moments, Hooke's law, diffraction, threshold frequency, gravitational field (also tested in 2017 paper), magnetic flux density, magnetic flux linkage, root mean square value of alternating current (also tested in 2017 paper), photon, random process, spontaneous process, internal energy, first law of thermodynamics, ideal gas, simple harmonic motion were tested.
- Due to this emphasis on definitions for the A Levels, I have personally prepared definition lists for my students to make it easier and more efficient for your revision.
- Calculation questions are generally manageable, other than P3/Q6(c), so you should be able to solve most of them, just be vigilant and careful to avoid careless mistakes.
- A Levels also like to place some emphasis on graphical sketching and graphical analysis skills so make sure you are comfortable with interpreting graphs especially for the gradient of the graph and the area under graph.
- For explanation questions, the topics that they like to ask include electromagnetic induction with the use of Faraday's law and Len's Law (Tested in P3/Q4b), Quantum Physic (Tested in P2/Q4), explain whether motion can be considered as simple harmonic (Tested in P3/Q9). Hence, you should be well prepared for these topics.
- Overall, I would say that the 2 papers are very manageable and you should have ample time to complete and double check your answers. Good and targeted preparation are key to excel in this paper.

2018 A Level H2 Physics P2 Suggested Answer Key (9749)

Q1 Topics: Forces on the definition of principle of moments, free body diagram and net force

(a)	• A body in equilibrium does not have any resultant moment about any pivot.	[1]
(b) (i)	For net force = 0N, $T_A+T_B=W$ Given that the ratio of the tensions in the two supports is $\frac{3}{7}$, the ratio of tension in support A to total tension is $\frac{3}{10}$ and the ratio of tension in support B to total tension is $\frac{7}{10}$. Hence, $T_A=(4.5)(9.81)(0.7)=30.9N$ $T_B=(4.5)(9.81)(0.3)=13.2N$ Comments • Based on the diagram given in the question, the surface area is greater on the side of A compared to the side of B. • Hence, the tension at A should be greater compared to the tension at B.	[2]
(ii)	Taking pivot about support A, clockwise moment=anticlockwise moment $W(d-0.20)=T_B(1-0.2-0.2)$ $4.5g(d-0.20)=(4.5g)(0.3)(0.6)$ $d-0.20 = 0.18$ $d=0.38m$	[2]
(c)	• For the sign to be in equilibrium position, there should not be any resultant force acting on the sign. • Since the wind is exerting a force on the sign to the right, there needs to be a force exerted by each support to the left to ensure that the resultant force in the horizontal direction is 0N.	[1]
		[Total: 6]

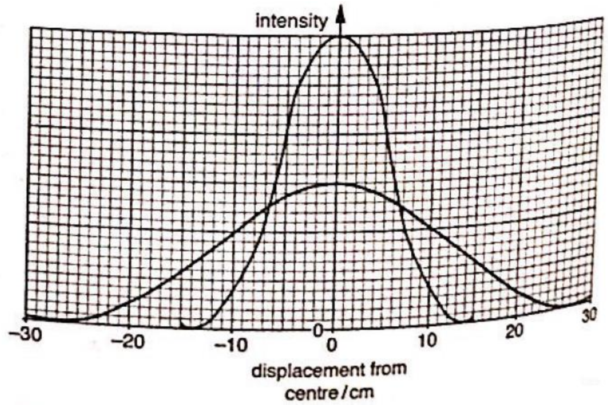
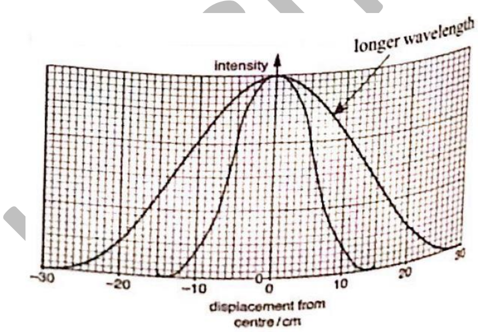
Q2 Topics: Forces, Work Energy and Power, Circular Motion

(a)	Hooke's law states that within the limit of proportionality, the extension or compression of a spring is directly proportional to the force applied to it.	[1]
(b)	EPE = Area under the load-compression graph $= 0.5Fx = (0.5)(6.8)(85\times10^{-3}) = 0.289J$	[2]
(c)	Based on conservation of energy, Loss in EPE = Gain GPE + gain in KE $0.289 = (0.042)(9.81)(0.40) + (0.5)(0.042)v^2$ $v = 2.43ms^{-1}$.	[3]

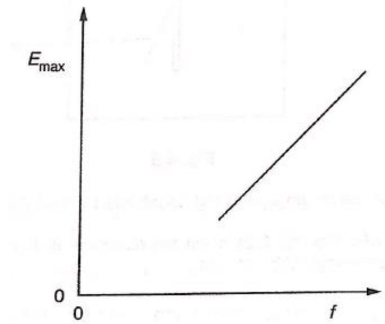
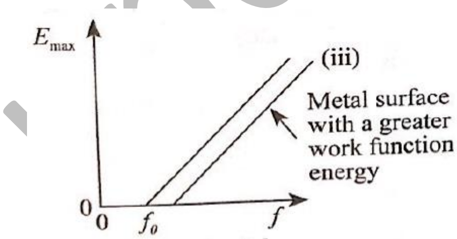
(d) (i)	At point P, $N+W=\frac{mv^2}{r}$ $N=\frac{mv^2}{r}-W$ For the ball to stay in contact with the track, $N \geq 0$ Hence, $\frac{mv^2}{r} \geq W \Rightarrow \frac{v^2}{r} \geq g$ In other words, this means that the centripetal acceleration must be greater than the acceleration of free fall. $\therefore v \geq \sqrt{rg}$ $v \geq \sqrt{(0.20)(9.81)} = 1.40ms^{-1}$ <u>Comments</u> • We should draw a free body diagram identifying all the forces acting on the ball at point P to deduce the equation $N+W=\frac{mv^2}{r}$	[3]
(ii)	V_{min} does not change as the condition of centripetal acceleration being greater than the acceleration of free fall is independent of the mass of the ball.	[1]
		[Total: 10]

Q3 Topics: Superposition on single slit diffraction

(a)	• Diffraction is the spreading of wave through an aperture or bending of wave around an obstacle. It is observable when the wavelength is of the same order of magnitude to the dimension of the aperture or obstacle. <u>Comments</u> • We cannot define diffraction as the bending of light because the wave may not be a light wave.	[1]
(b)	For single slit diffraction, $\sin\theta=\frac{\lambda}{b}$ where θ is the angle between the central maximum to the first minimum measured from the single slit. From Fig. 3.2, the displacement from the central maximum to the first minimum is 14cm. Hence, $\theta=\tan^{-1}\left(\frac{14\times10^{-2}}{2.7}\right)=2.9682^0$ $\lambda=b\sin\theta=\left(12\times10^{-6}\right)\left(\sin 2.9682\right)=6.21\times10^{-7}m$	[3]
(c)	• When the single slit is narrower, slit width b decreases. Hence, θ value will increase as $\sin\theta=\frac{\lambda}{b}$. This means that the displacement from the central maximum to the first minimum will increase.	[2]

	• When the slit is narrower, less light is able to pass through the slit. Hence, the intensity will also fall.  	
(d) (i)	State and explain the changes to the observed diffraction pattern in Fig 3.2 when visible light of a longer wavelength is used. • When visible light of a longer wavelength is used, the θ value will increase as $\sin\theta = \frac{\lambda}{b}$ and there is greater diffraction occurring. This means that the displacement from the central maximum to the first minimum will increase on both sides of the central maximum. • However, there will be no change to the intensity as the same amount of light will pass through the slit.  	[2]
(ii)	• The different wavelengths in white light diffract at different angles and constructively interfere at <u>different angular positions</u>, with the longer wavelength further away from the centre. • However, all wavelengths constructively interfere at θ=0^0. Thus they overlap and produce the white central region.	[2]
		[Total: 10]

Q4 Topics: Quantum Physics on Photoelectric Effect

(a)	• Threshold frequency is the minimum frequency of the incident electromagnetic radiation on a cold and clean metal surface such that the individual photons possess energy greater than the work function of the metal. • Then photoelectrons can be emitted from the metal's surface.	[2]
(b)	 Fig. 4.1 Just extend the line in Fig4.1. above until it intersects with the x axis and the value will be the threshold frequency.	[1]
(ii)	Based on the photoelectric effect equation, $hf = \phi + E_{max} \Rightarrow E_{max} = hf - \phi$ Hence, the gradient of the line is the Planck's constant value.	[1]
(iii)	• For a metal surface with greater work function, the threshold frequency value becomes greater and E_{max} value becomes lower at each frequency value. Hence, the line will shift to the right.  	[1]
(c) (i)	Based on the photoelectric effect equation, $hf = \phi + E_{max} \Rightarrow \frac{1}{2} m v_{max}{}^2 = hf - \phi$ $v_{max} = \sqrt{\frac{2(hf - \phi)}{m}} = \sqrt{\frac{2(6.63\times10^{-34})\left(\frac{3\times10^8}{490\times10^{-9}}\right) - 2(2.5)(1.6\times10^{-19})}{9.11\times10^{-31}}}$ $= 1.14\times10^5\, ms^{-1}$	[4]

(ii) 1.	• Blue light frequency is higher than the threshold frequency of europium. Hence, photoelectrons can be emitted from europium's surface, causing both the gold leaf and the metal rod to lose their negative charge. Hence, repulsion between the metal rod and gold leaf decreases and the gold leaf falls. • In contrast, red light frequency is lower than the threshold frequency of europium. Hence, no photoelectrons are emitted from europium's surface and the repulsion between the metal rod and gold leaf remains. Hence, the gold leaf remains in its position.	[1]
2.	• Further loss of photoelectrons due to light having frequency above the threshold frequency of europium metal will result in a more positively charged gold leaf and metal rod. • Hence, the repulsion between gold leaf and metal rod increases and the gold leaf will rise further. • When no photoelectrons are emitted as light has frequency lower than threshold frequency of europium metal, the repulsion between gold leaf and metal rod remains and the gold leaf will not fall.	[2]
		[Total:12]

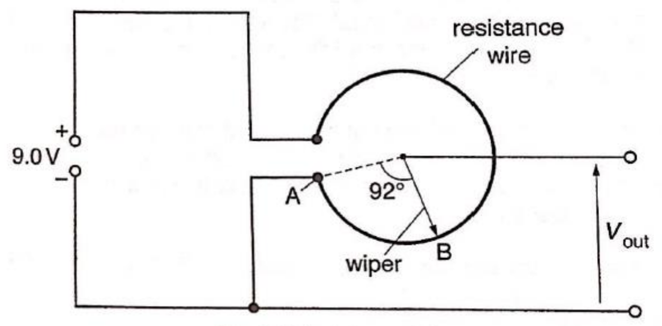
Q5 Topics: Current and Electricity, Electric Field

(a)	Given the density of copper, it means that in a volume of 1m^3, the mass of copper is 8960kg. No. of moles of copper in 8960kg $=\frac{8960}{0.0635}$ Hence, the number of copper atoms $=\frac{8960}{0.0635}\times 6.02\times 10^{23}=8.4943\times 10^{28}\,atoms$ Since copper has one conduction electron per copper atom, The number of conduction electrons in a volume of 1m^3 is also 8.49×10^{28} (shown)	[3]
(b)	A tungsten wire of diameter 0.36mm has resistance 30Ω. The power dissipated in the wire is 5.0W. The number density of charge carriers in tungsten is 3.4 x 10^{28}m^{-3}. Calculate the average drift velocity v of the conduction electrons in tungsten. Since P=I^{2}R, Hence, $I=\sqrt{\frac{P}{R}}=\sqrt{\frac{5.0}{30}}=0.40824A$ Given $I=Anve$, $\Rightarrow v=\frac{I}{Ane}=\frac{0.40824}{\pi\left(0.18\times 10^{-3}\right)^2\left(3.4\times 10^{28}\right)\left(1.6\times 10^{-19}\right)}$ $=7.37\times 10^{-4}\,ms^{-1}$ <u>Comments</u> Note that in this part of the question, the metal has been changed to tungsten so the number density should be 3.4×10^{28} and not 8.49×10^{28} which belongs to copper.	[4]

(c)	The wire in (b) is now replaced with another tungsten wire of the same diameter but twice the length. The potential difference (p.d.) across the wire is unchanged. The temperature of both wires is the same. State and explain the change to the drift velocity of the electrons in the second wire. • Since $R=\frac{\rho l}{A}$, resistance of the wire is proportional to the length of the wire and inversely proportional to the square of the diameter, so resistance of the wire will be doubled. • Also, as potential difference across wire remains unchanged, the electric field strength in the wire is halved now since $E=\frac{V}{l}$. Hence, the electric force and acceleration experienced by the electron will also be halved. • Thus, the drift velocity, v=at, of the electrons in the second wire will be half that in the first wire, to result in half the current. <u>Comments</u> • The above explanation is more intuitive and links more directly to the drift velocity of electrons in the second wire. • Alternatively, students can explain that since V=RI, when R is doubled, to keep potential difference across the wire unchanged, current I has to be halved. • Then, since I=Anve, given that cross sectional area A is the same as the diameter of the 2 wires are the same, number density n is the same as the metal is kept constant as tungsten, when I is halved, drift velocity will be halved as well. • Temperature will also affect the resistance of the wire, so it has to be kept constant here.	[3]
		[Total: 10]

Q6 Topic: DC Circuit with the use of potential divider rule

(a)(i)	As P and Q are connected in series, the current in Q is also 27mA. $V_{out}=RI=(90)\left(27\times10^{-3}\right)=2.43V$	[1]
(ii)	Examining Fig 6.1, the resistance in P is $\frac{9.0-2.43}{27\times10^{-3}}=243.33\Omega$ Effective resistance between thermistor and Q in Fig 6.2 = $\left(\frac{1}{120}+\frac{1}{90}\right)^{-1}=\frac{360}{7}\Omega$ Applying potential divider rule, $V_{out}=\frac{\frac{360}{7}}{243.33+\frac{360}{7}}\times9.0=1.57V$	[3]
(iii)	• When temperature of the thermistor increases, the resistance across the thermistor will decrease. • Hence, the effective resistance between thermistor and Q will decrease. • Since e.m.f remains the same, the current delivered by the battery increases. • This increases the p.d. across resistor P	[3]

	• Since V_{out} = e.m.f – p.d. across resistor P, V_{out} decreases <u>Comments</u> • As the mark weightage is high in this question, we should elaborate and try not to just say that applying potential divider rule, when effective resistance between thermistor and Q decreases, V_{out} decreases.	
(b)	A rotary potentiometer is illustrated in Fig. 6.3.  **Fig. 6.3** (not to scale) Length of AB= $(2\pi)(1.2\times10^{-2})\left(\frac{92}{360}\right)=1.9262\times10^{-2}\,m$ Hence, applying potential divider rule, V_{out} = $\frac{1.9262}{6.5}\times9.0=2.67V$ <u>Comments</u> • Note that the total length of the resistance wire 6.5cm is shorter than the circumference of the circle which is given by 2π(0.012)=7.5cm. • We need to observe from the diagram that the p.d. across AB is equal to the output voltage.	[3]
		[Total:10]

Q7 Topics: Quantum Physics, Current and Electricity, Direct Current, Graphical analysis skills, Data analysis skills

(a)	With reference to Table 7.1, the p.d. increases at an increasing rate with respect to the frequency f as f increases. <u>Comments</u> • It may not be sufficient to state that the p.d. increases as frequency increases. • From the table, it may not be obvious that V is increasing at an increasing rate. This can be verified later on in (b)(iii) when n value is found to be 2.29 given $V=kf^n$.	[1]
(b) (i),(ii)	Simple graph plotting	[2]
(iii)	Given $V=kf^n$ lgV = lgk + nlgf Hence, n is the gradient of the curve. n= $\frac{0.64-0}{14.84-14.56}=2.29$ <u>Comments</u> Graphical analysis skills is required here	[2]
(c)(i)	Frequency of the LED light = $\frac{c}{\lambda}=\frac{3\times10^8}{520\times10^{-9}}=5.7692\times10^{14}\,Hz$ lgf=14.761 The corresponding lgV value from the graph is 0.46 Since lgV=0.46, $V=10^{0.46}$=2.88V <u>Comments</u> Graphical analysis skills is required here	[3]
(ii)	$P=\frac{E}{t}=\frac{nhf}{t}\Rightarrow\frac{n}{t}=\frac{P}{hf}=\frac{10}{3.8\times10^{-19}}=2.6316\times10^{19}$ 2.6316×10^{19} is the number of photons released in 1.0 second. Hence, the number of photons released in 1.0 minute is: $=\left(2.6316\times10^{19}\right)(60)=1.58\times10^{21}$ <u>Comments</u> Application of knowledge from topic of quantum physics is required here.	[2]
(iii)	• We need to understand that there are two resistors connected in series: LED and the series resistor. Hence, the p.d. across the resistor is not equal to the e.m.f value of 4.5V, but less than that. • The exact p.d. value can be calculated through the following: The p.d. across LED emitting photons of wavelength 520nm is 2.88V (from (c)(i)) Hence, p.d. across series resistor is 4.5-2.88=1.62V • It is stated in the article that the normal operating current through an LED is 20mA. • Thus, resistance of the series resistor, $R=\frac{V}{I}=\frac{1.62}{20\times10^{-3}}=81\Omega$ <u>Comments</u> • Some students got confused as they try to make use of the results in (ii) to do this part of the question, which is not necessary here.	[2]

(d)	• The power supply is able to deliver a current of 730mA over a period of 1 hour or 3600s. • Hence, the total charge supplied in 1 hour is $(730\times10^{-3})(3600)=2630C$	[2]
(e)	The extract stated: A 60W incandescent lamp produces an illumination of 840 lumens whereas an LED lamp produces an illumination of 800 lumens for a 10W power consumption. $\frac{\text{efficiency of LED}}{\text{efficiency of incandescent lamp}}=\frac{800/10}{840/60}=5.71$ Comments Efficiency is calculated by taking output quantity/input quantity.	[2]
(f) (i)	• From the passage, LEDs are more efficient than incandescent lamps. • This can be calculated where $\frac{\text{efficiency of LED}}{\text{efficiency of incandescent lamp}}=\frac{800/10}{840/60}=5.71$ • Similarly, CFLs are more efficient than incandescent lamps. • This can be calculated where $\frac{\text{efficiency of CFL}}{\text{efficiency of incandescent lamp}}=\frac{800/14}{840/60}=4.08$ • Also, the capital cost of using incandescent lamp for 50k hours is the highest at \$52.50 (42x1.25) while the capital cost of using LED and CFL for 50k hours are \$35.95 and \$19.75 (3.95x5) respectively. • Furthermore, incandescent lamps need to be changed more frequently which results in higher manpower and logistics costs. • Hence, LEDs and CFLs are replacing incandescent lamps in the home. Comments • We did not bring in operating cost or total cost here because the next part of the question requires us to calculate these values. • Some students did not read the question carefully and miss out the part that you are allowed to bring in data from the passage to answer this question. • Data analysis skills is required here.	[2]
(ii)	For 50k hours of use, Operating cost of LEDs= 0.22Pt = (0.22)(0.010)(50000) = \$110 Operating cost of CFLs= 0.22Pt = (0.22)(0.014)(50000) = \$154 • Since the operating costs of one traffic light using LED is lower compared to using CFLs, the LTA should replace all the CFLs used in traffic light in Singapore with LEDs. • Also, LEDs need less frequent replacements since it can operate for 50k hours while CFLs can only operate for 10k hours. Hence, this reduce manpower and logistics costs required.	[3]

(iii)	• As incandescent lamps are not as efficient compared to LEDs and CFLs, larger amount of thermal energy may be generated. • This will be useful in melting the snow which would otherwise cover the traffic lights. <u>Comments</u> • A thinking question where you will have to think about the implication and thus the advantage of having incandescent lamps not being as efficient compared to LEDs and CFLs here.	[1]
		[Total: 22]

End of solutions