VCE Physics
Solutions to the 2018 Paper - Final version.
Suggested Marking Scheme in italics
Consequentials are indicated as "Conseq on 1"

These suggested solutions have been prepared by Vicphysics Teachers' Network. Their purpose is to assist teachers and students when using this exam paper as a revision exercise. Additional questions using the stem in the exam questions are provided on the last page.

Every effort has been made to check the solutions for errors and typos.

Section A

1 B Using F = BIl, F = $4.0 \times 10^{-4} \times 10 \times 0.10 = 4.0 \times 10^{-4}$ N [89%]

2 A Using Hand rule, direction of force is out of page. [78%]

3 A Using right hand grip rule, field is to the right on the front side of the wire. [90%]

4 D Using $E = kq/r^2$, $E = 8.99 \times 10^9 \times 2.0 \times 10^{-6} / (3.0)^2$ approx 2.0×10^3 V m^{-1} [81%]

5 C Net force LR = 30 N to left, Net force up down = 20 N up , toatl net force = $\sqrt{20^2 + 30^2} = \sqrt{1300}$ = 36.1 N [74%]

6 C Braking force = ma = 1000 x (20 - 0)/ (3.0 - 0.5) = 1000 x 20/2.5 = 8000 N = 8.0 kN [69%]

7 A Grav field strength $\propto (1/r^2)$, so at 2R above the surface, so 3R from the centre of the earth, the field strength = (1/9) x 9.76 = 1.08 N kg^{-1} [16%] B was the most common wrong answer, because the phrase '**above** the surface of the earth' was missed.

8 C By Cons of momentum, 10 x 6.0 = (10 + 5.0) x v, so v = 60/15 = 4.0 m s^{-1} [86%]

9 B Momentum is always conserved, KE is always lost in 'sticky' collisions. [71%]

10 D Sound is a longitudinal wave, so vibration is in the direction of the propagation. [59%]

11 D Doppler shift, the frequency of sound from an approaching sources is increased. The speed of sound depends on the medium, the amplitude is unchanged and the period is less. Alternative C was also marked correct as the question could have been interpreted as the fire engine being closer and therefore louder because of a larger amplitude.[88% chose, 7% chose C]

12 C To increase the spacing in an interference pattern, you need to move the slits closer together or increase the wavelength. Changing the slit width affects the diffraction from each slit, but not the interference between them. Moving the screen further away would increase the distance between adjacent dark bands. [55%]

13 D For speed = 0, $\gamma = 1$, so either B or D, as speed approaches c, γ approaches ∞ so D. [58%]

14 B Relativistic KE = $(\gamma - 1)mc^2$, for relativistic speeds this will be greater than $½mv^2$, because the a fast moving proton has more mass than a slow moving proton. [60%]

15 D The slit reduces the uncertainty in the y position, so the uncertainty in the momentum increases producing the spread. [49%]

16 C Only transverse waves can be polarised. [84%]

17 A The larger work function means a y intercept with a larger negative value, but an unchanged gradient. [70%]

18 A The experimental uncertainty in a (single) measurement comes from the scale or the digital display of the measuring instrument. Answer A fits well, but the use of the word 'doubt' is imprecise, a better word would have been 'limitation'. Answer C may have merit if the quantity of a physical constant, such as the mass of an electron, but the mass of a lump of plasticine does not really have a 'true value'. [57%]

19 B Typically the uncertainty is half of a division (0.5 A), but in instances where the lines in the scale are widely spaced as in this case, and the scale can be read more finely, then the uncertainty is one-fifth of a division (0.2 A), but this answer is not provided, so the best answer is 0.5 A. [70%]

20 B The rotation speeds are chosen, so this is the independent variable, the peak EMF changes as a result and is the dependent variable, while the magnetic filed strength is fixed and is the controlled variable. [82%]

Section B

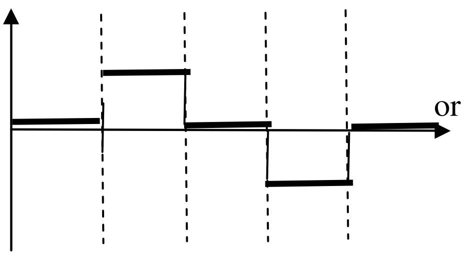
1a 5.0×10^4 V m^{-1} Using E = V/d, E = 10,000V / (0.20) = 5.0×10^4 V m^{-1} *(1)* [0.82/1,82%]

1b 1.4×10^6 m s^{-1} Using Vq = ½mv^2, v = √2Vq/m = √2 x 10,000 x 1.6 x 10^{-19} / (1.7 x 10^{-27}) *(1)*
v = 1.4×10^6 m s^{-1} *(1)* [1.2/2 , 60%]

1c 0.53 m Using r = mv/Bq, r = (1.7 x 10^{-27} x 1.0 x 10^6) /(2.0 x 10^{-2} x 1.6 x 10^{-19}) *(1)*
r = 0.53 m *(1)* [1.35/2 , 67%]

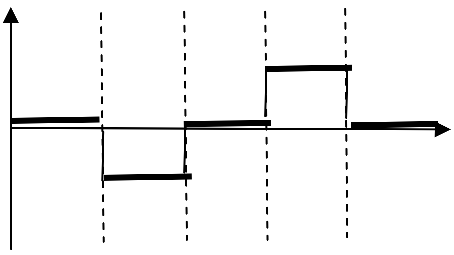
2a 6.4×10^{-4} V Average EMF = n x (change in flux) / (time taken), where flux = BA, *(1)* so
Average EMF = 10 x (2.0 x 10^{-2} x 1.6 x 10^{-3} - 0) / (0.50) *(1)* = 6.4×10^{-4} V. *(1)*
[2.4/3, 80%]

2b As the loop enters the field, the amount of flux pointing downwards is increasing, so a current is induced. The direction of this current is such that it opposes the change in magnetic flux, that is, it will point up. To produce this field there must be an anticlockwise current in the loop that leaves the top lead of the loop. Depending on how the terminals of the voltmeter are connected to the loop the voltage will look like either of the two graphs below.
Note that when the loop is leaving the field, the amount of flux downwards is decreasing, so the induced current and its field will be the reverse of the previous situation.
(1) Zero EMF in 1st, 3rd and 5th intervals, *(1)* Constant in 2nd and 4th intervals, *(1)* polarities in 2nd and 4th intervals are opposite. [1.4/3, 47%]



If EMF is measured from the top lead from the loop to the bottom lead.

or



If the EMF is measured from the bottom lead from the loop to the top lead.

3a C From the signs on the terminals of the battery, conventional current is in the direction H, G, F and E *(1)*. The magnetic field is left to right, so using your hand rule, the direction of the force on FE is up and on HG is down *(1)*, so the direction is clockwise (C). *(1)* [1.97/3, 66%]

3b The split rings reverse the direction of the current in the loop twice every rotation when the loop is perpendicular to the magnetic field. This reverses the direction of the two magnetic forces and allows to loop to continue turning. With slip rings there is no reversal of current so that when the loop reaches the position perpendicular field, the two forces are now acting in the same line, but in opposite directions and so act to pull the loop apart. *(1)* So the loop will turn through 90 degrees and then stop. *(1)* [0.65/2, 32.5%]

4a 2.8 V The V_{peak} = 4.0 V, so using $V_{peak} = V_{RMS} \times \sqrt{2}$, $V_{RMS} = 4.0 / \sqrt{2}$ *(1)*
V_{RMS} = 2.8 V *(1)* [1.1/2, 55%]

4b The rate of rotation is doubled so the period is halved to four divisions. *(1)* The change in flux happens in half the time so the V_{peak} is doubled to 8.0 V. *(1)*
[1.2 /2, 60%]

5a 48 W The transformer will step down the voltage by a factor of 4 and increase the current by a factor of four, so the current in the light globe circuit is 3.0 x 4 = 12 A. *(1)* Power dissipated, P = VI = 4.0 x 12 = 48 W. *(1)* [0.9/2, 45%]

5b 40 V Voltage across the primary turns of the transformer = 4 x 4.0 = 16 V, *(1)* but the voltage drop across the t'n lines, using V=IR, is 3.0 x 8.0 = 24 V *(1)*. So the voltage at the power supply = 16 + 24 = 40 V. *(1)* [1.3/3, 44%]

5c 72 W Power loss = $I^2R = 3.0^2 \times 8.0$ *(1)* *(1)* = 72 W *(1)* [1.5/2, 75%]

5d	18 W	If the light operates correctly then the current in the light globe is still 12 A, but now the current in the transmission lines will be 12 / 8 = 1.5 A or halved because the ratio has been doubled. *(1)* So now the power loss = 1.5^2 x 8.0 *(1)* = 18 W*(1)* or a quarter of the previous answer (Conseq on 5c). [0.7/3, 24%]
5e		i) To lower the current in transmission lines for the same power transfer *(1)* and ii) to reduce power loss in transmission lines. *(1)* [1.3/2, 66%]
6a		When the ball and the spring come to rest, then the Grav PE of the ball before release is now stored as Elastic PE. The ball fell 2.5 m, so mgh = $½kx^2$ *(1)*, 2.0 x 9.8 x 2.5 = 0.5 x k x 0.50^2 *(1)*, so k = 392 N m^{-1}. *(1)* [1.5/3, 48%]
6b	0 m s^{-2}.	0 m s^{-2} *(1)*. Maximum speed will be reached when the weight force and the spring force balance with the net force = zero. Prior to this compression, the upward spring force will be less than the weight force and so the ball will still be gaining speed. After this point the upward spring force will be greater than the weight force and so the ball will be slowing down. *(1)* [0.26/2, 13%]
6c	0.05 m	At its maximum speed, the forces balance, so mg = kx, that is, x = mg/k *(1)* Compression = 2.0 x 9.8 / 392 = 0.05 m. *(1)* [0.27/2, 13%]
7a	1.2 m.	Horiz: Constant speed, so dist = speed x time = 3.0 x 0.40 = 1.2 m. *(1)* [0.79/1, 79%]
7b	0.80 m	Vert: u = 0, a = 10, t = 0.4, s = ? use s = ut + $½at^2$, so s = 0 + 0.5 x 10 x 0.4^2 *(1)* s = 0.80 m *(1)* [1.3/2, 67%]
7c	5.0 m s^{-1}	Speed of impact = $\sqrt{3.0^2 + v_{vert}^2}$ *(1)*. u = 0, a = 10, t = 0.4, v = ?, use v = u +at v_{vert} = 4.0 m s^{-1} *(1)*, so speed of impact = $\sqrt{3.0^2 + 4.0^2}$ = 5.0 m s^{-1} *(1)* [1.5/3, 49%]
8a	8.0 N	Accel'n = 40 / Total mass = 40 / (4.0 + 1.0) = 8.0 m s^{-1} *(1)*. Using Net F = ma for mass B, $F_{on\ B\ by\ A}$ = $Mass_B$ x accel'n_B = 1.0 x 8.0 = 8.0 N *(1)* [0.71/2, 35%]
8b	8.0 N, to left	By Newton's 3rd law, the two forces are equal in magnitude *(1)* and act in opposite directions. *(1)* [1.5/2, 73%]
9a	4500 N	At r = 2.0 x 10 m, g = 3.0 N kg^{-1} *(1)*, so grav force = mg = 1500 x 3.0 = 4500 N. *(1)* [1.2/2, 60%]
9b	1.2 x 10^{12} J	Change in grav PE = mass x Area under field vs distance graph *(1)*. Use trapezium to calculate area as it is quicker. Change in GPE = 1500 x (13 + 3)/2 x (2 - 1) x 10^8 = 1500 x 8 x 10^8 J *(1)* Change in GPE = 1.2 x 10^{12} J *(1)* [1.3/3, 44%]
9c		Using $GM/r^2 = 4\pi^2r/T^2$, $T = \sqrt{4\pi^2r^3/GM}$ *(1)* $T = \sqrt{4\pi^2 \times (6.70 \times 10^8)^3 / (6.67 \times 10^{-11} \times 1.90 \times 10^{27})}$ *(1)* T = 3.06 x 10^5 s *(1)* [1.9/3, 63%]
10a	3.3 x 10^3 m	Only force acting is the weight force so mg = mv^2/r, r = v^2/g *(1)* = $180^2/9.8$ r = 3306 m = 3.3 x 10^3 m *(1)* [1.3/2, 64%]
10b	No. *(1)* Zero gravity experience means that the passenger is in free fall, with the only force acting is the gravity force producing an acceleration of 9.8 m s^{-2} because the reaction force from surfaces in the plane are zero. *(1)* [1.2/2, 59%]	
11a	1.00 m	Using v= fλ, λ = 340 /340 = 1.00 m *(1)* [0.92/1, 92%]
11b	0.75 m	Note: The question does not specify the polarity of speakers A and B. If the two speakers were out of phase, that is, if the connection of the wires from the amplifier to one of the speakers were reversed, then when the waves from the two speakers met in the middle they would cancel each other out producing a quiet region. So assuming the wires are correctly connected, the middle would be a quiet region and at the first region of quietness, the path diff would be 0.5 λ, at the second region of quietness, the path diff would be 1.5 λ *(1)*. To achieve a path diff of 1.5 λ, you need to have moved half that distance, that is 0.75 λ, because you will be 0.75 λ closer to one speaker and is 0.75 λ further away from the other, giving a path difference of is 1.5 λ. 0.75 λ = 0.75 x 1.00 = 0.75 m. *(1)*

If an answer explicitly assumed the speakers were out of phase, then the second region of quietness would a path diff of 2.0 λ, and so the student would have moved 1.0m. [0.58/3, 19%]

12a 5.3×10^{14} Hz — Using v= fλ, f = $3.0 \times 10^{8} / 565 \times 10^{-9} = 5.3 \times 10^{14}$ Hz *(1)* [0.72/1, 72%]

12b 60.3^0 — Using $n_{core} \times \sin \theta_c = n_{cladding} \times \sin 90^0$, $\sin \theta_c = 1.45 / 1.67$ *(1)*, $\theta_c = 60.3^0$ *(1)* [1.45/2, 72%]

12c 1.80×10^{8} m s^{-1} — $v_{core} = c / n_{core} = 3.0 \times 10^{8} / 1.67$ *(1)* = 1.80×10^{8} m s^{-1} *(1)*. Note: The speed of light in the formula sheet is given to only two significant figures. This is an oversight. [0.95/2, 47%]

13a 1.5×10^{16} — Energy of one photon, E = hc/λ = $6.63 \times 10^{-34} \times 3.0 \times 10^{8} / (610 \times 10^{-9})$ J *(1)*
No of photons per second = 5.03×10^{-3} / (energy of one photon)
Number = $5.03 \times 10^{-3} \times 610 \times 10^{-9} / (6.63 \times 10^{-34} \times 3.0 \times 10^{8})$ *(1)* = 1.5×10^{16} *(1)*
[1.0/3, 33%]

13b The path difference for light from the two slits, S_1 and S_2, to C on the screen is zero *(1)*, which means the light from the two slits reinforce producing constructive interference and a bright band, which in wave terms is crest meeting crest. *(1)* [1.1/2, 53%]

13c Path difference = 2.14×10^{-6} m, the wavelength = 610×10^{-9} m or 0.610×10^{-6} m. Dividing the wavelength into the path diff gives = 2.14 / 0.610 = 3.5 wavelengths *(1)*, X should be on the fourth black band to the right of C, that is, the second from the right end. *(1)* [0.99/2, 49%]

14 The use of the imperative 'must' and the word 'speed' and not 'velocity' complicates this question. If the word 'must' implies a closer and more careful examination of possible interpretations of the question, then it can be argued that a spaceship in orbit is travelling at a constant speed, but could be moving a circle accelerating and so accelerating, so it is not in an inertial frame. This would support the answer No.
However with a cursory approach to the question, not looking for subtlety, then on face value, the answer is No, as the spaceship can be assumed to be travelling in a straight line, and so is not accelerating. [0.36/2, 13%] The low score suggests most students did not pick up the hidden subtlety in the question.

15 6.3×10^{21} J — Moving clocks run slow by the Lorentz factor, so $\gamma = 8.0$.
The relativistic KE = $(\gamma\text{-}1)mc^2$ *(1)* = 7 x 10,000 x $(3 \times 10^{8})^2$ *(1)* = 6.3×10^{21} J *(1)*
[1.3/3, 43%]

16 14 hours — The observed period of the quasar is less than the period in the quasar's reference frame, So this period = 20 /1.41 *(1)* = 14 hours *(1)* [1.1/2, 54%]

17a i) Kym *(1)* — [0.78/1, 78%]

17a ii) There is more energy in the light and from a wave point of view, a larger amplitude so more energy to spread across the electrons *(1)*, and with a longer waiting time, there is more time for the photoelectrons to accumulate enough energy to leave the surface. *(1)* [0.62/2, 31%]

17b 5.4×10^{-15} eV s — Planck's Constant = gradient. The x-intercept is 7.0×10^{14} Hz, so using the highest data point, gradient = $2.7 / ((12 - 7) \times 10^{14})$ *(1)* = 5.4×10^{-15} eV s *(1)*
[1.0/2, 52%]

17c 4.0 eV — Extending the line of best fit to the y axis *(1)* gives 4.0 eV *(1)*
Using the threshold frequency, Work function = threshold frequency x Planck's Constant =$7.0 \times 10^{14} \times 5.4 \times 10^{-15}$ 3.8 eV. [0.92/2, 46%]

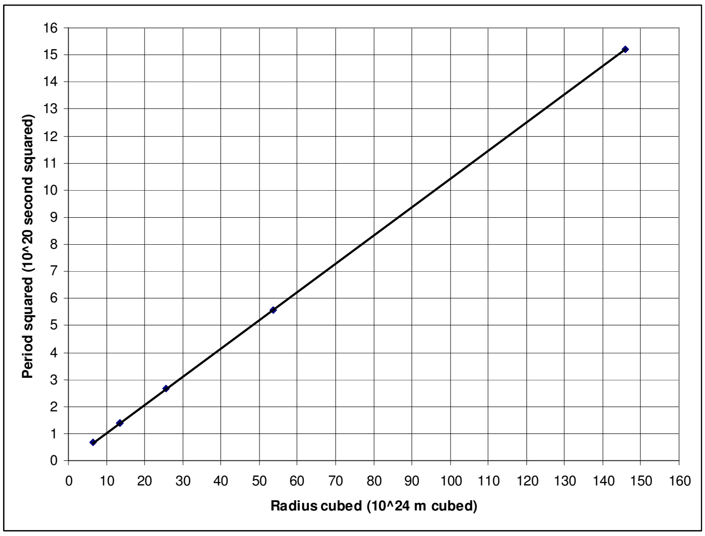
18a 0.155 nm — The wave lengths are the same, so the wavelength of the x-ray photon, λ = hc/E, $\lambda = 4.14 \times 10^{-15} \times 3.0 \times 10^{8} / 8000 = 1.55 \times 10^{-10}$ *(1)* = 0.155 nm *(1)* [1.0/2, 51%]

18b 2.0×10^{-17} J — KE = ½$mv^2 = p^2/2m$, but p = h/λ, so KE = $h^2 / (\lambda^2 \times m)$ *(1)*
KE = $(6.63 \times 10^{-34})^2 / ((1.55 \times 10^{-10})^2 \times 9.1 \times 10^{-31})$ *(1)* = 2.0×10^{-17} J *(1)* [0.97/3, 33%]

19a Red — Red has the longest wavelength *(1)* [0.64/1, 64%]

19b Electrons in atoms can only have discrete energy values *(1)*. When the atoms in a gas are heated and the electrons have high energy values, they can only drop down to one of these discrete energy values. In so doing a photon is emitted with an energy equal to the difference between the two energy values *(1)*. This particular photon energy corresponds to a particular colour. *(1)* [0.72/3, 24%]

20a Scales: Y axis: one division = 1 x 10^{10} s^2 *(1),* X axis: one division = 10 x 10^{24} m^3. *(1)*. Correct plotting: *(2),* Correct line of best fit *(1)* [4.2/5, 85%]



20b 1.0 x 10^{-15} s^2m^{-3} Gradient *(1)* = 0.10 x 10^{-14} s^2m^{-3} *(1)* [1.25/2, 62%]

20c 5.9 x 10^{26} kg Gradient = $T^2/R^3 = 4\pi^2/GM$ *(1)*, so $M = 4\pi^2/(G \times \text{gradient})$ *(1)*
M = 5.9 x 10^{26} kg *(1)* [1.15/3, 38%]

Additional Questions using the stem in the exam questions

Section A

2 For each of the alternative directions of the force acting on the wire, explain what changes need to be made to the figure to give that answer.

6
- a) Calculate the distance travelled by the car from the instant of seeing the dog to stopping.
- b) Calculate the work done by the braking force.
- c) Calculate the change in kinetic energy of the car.
- d) Comment on your answers to b) and c)

7 Calculate the distance from the centre of the Earth at which the gravitational field strength equals each of the incorrect answers.

8
- a) Calculate the change of momentum of trucks X and Y
- b) Assume the duration of the impact is 0.30 s, calculate the magnitude of the force on X by Y and the force on Y by X.
- c) calculate the accelerations of trucks X and Y
- d) Calculate the distances travelled by trucks X and Y during the collision
- e) Explain your answers to Q'n d

13 What is the value of the y intercept in the graph of the correct answer?

Section B

1
- d) Calculate the magnitude of the electric force on the proton and the proton's acceleration.
- e) Determine the speed at which the initial proton leaves the magnetic field.

5
- f) Using the conditions in d), calculate the voltage at the variable power supply and the power supplied.

6
- d) Draw the following graphs on the one set of axes: weight force vs distance, spring force vs distance and net force vs distance from where the ball is released to where it next stops.
- e) Draw acceleration vs distance and velocity vs distance graphs from where the ball is released to where it next stops.

8 Re do the question with friction force on A of 10 N and on B of 5 N

9
- d) Calculate the speed and kinetic energy of Juno.
- e) Extend the graph on the distance axis and calculate the gravitational potential energy from a distance of 2.0×10^8 m to infinity.

10
- c) To have a second zero gravity experience, the plane needs to execute a dip first. Assuming the same speed and radius, calculate the reaction force on the passenger of mass 70 kg by the plane as the plane goes through the dip.

20
- d) Assume the uncertainty in the orbital radius for each of the measurements in 0.005, that i.e. $1.86 \pm 0.005 \times 10^8$ m. Calculate the percentage error for each reading of the radius.
- e) The percentage error of the values for R^3 is three times the percentage error for R. Determine the percentage error in R^3 for the moons Mimas and Rhea.
- f) Use the calculated values in e) to determine the uncertainties in the values of R^3 for the moons Mimas and Rhea.
- g) Draw plot the data values for the moons Mimas and Rhea and use your answers in f) to draw in the error bars.
- h) Calculate the maximum and minimum values for the gradient of the line drawn between these two points.