T A S M A N I A N

C E R T I F I C A T E

O F E D U C A T I O N

Physics

Subject Code: PH866

2003 External Examination Report

General Comments

The distribution of marks obtained by candidates was approximately normal with average marks in each section being over 50%.

Two issues for moderation are:

Setting Standards:

For each criterion, the exam ratings were more stringent than those given by teachers. Nevertheless about 20% of candidates were given EA awards.

Notation on Graph Axis:

Many candidates had difficulty interpreting the 'power of 10' notation in the photoselective effect question, in spite of the fact that the exam used the same notation as is used in the recommended text. To avoid confusion in the future, we should adopt a standard notation which is mathematically unambiguous. One suggestion is along the lines:

Energy (in units of 10^{-19}J)

Question 1

(a) Most knew how to find the area under the graph. 25% of candidates made arithmetic errors. Most quoted correct units with answer.

(b) Most correctly divided the energy (from (a) above) by the total time to get full marks – even if (a) was incorrect 40% quoted correct units.

(c) Most accurately calculated points (table) however, few realised that efficiency dropped to zero after 5000kw – well before 5400kw.

(d) Many correctly identified points:

(i) Efficiency reduces when wind power >4200 kw
(ii) Efficiency = 0 when wind power >5000 kw. Protection, safety. Etc being acceptable reasons given.

Question 2

(a) Few saw that the P and V^3 relationship ceased soon after 10 m/s as the graphs gradient beings to decrease. Many focussed on other practical issues when the question related the shape of the graph to the validity of the relationship.

(b) Most plotted V^3 vs P or V vs P^{V3}. Note P^{-3} + $P^{1/3}$.

(c) Most plotted all values in the table leaving the relevant data very squashed up. As a result, calculation of slope was not accurate. Some used the ration of the value of a point from the table to find slope – however, they chose a point that was not on the linear section! Many 'line of best fit' joined (0, 0) to a later point not on the linear section!

(d) Well done by those attempting (60%).

Question 3

(a) Many slopes were poorly drawn with very small triangles constructed. This led to errors in determining the ratio of rise to run. Some did not find the tangent at 0. Some declared that a = 0 since v = 0.

(b) and (c) Well done by most.

(d) Answers acknowledging a balance between max V and max A were required.

Question 4

(a) (i) Very few mistakes.

(ii) Vector triangles and trigonometry were used to find the component from part (i) down the slope.

(iii) The net forces on a body moving at constant velocity are balanced, but the friction force is not zero. The friction force acts to oppose movement.

(iv) Many students left out the normal force that the slope exerts on the rock.

(b) (i) Very few mistakes

(ii) The majority of students used correct KE formula to find Joules and then converted to power. Most mistakes came from failure to square velocity.

(iii) Some students did not find the new velocity but incorrectly used existing value of 32 m/s.

(iv) The question incorrectly asked students to compare their answers for parts (i) and (ii), but most recognized that they should be comparing the force values. There were some good observations about the higher velocity from the smaller nozzle failing to produce a larger force, and the amount of water that each nozzle would displace.

Question 5

(a) (i) This question was generally well done with about 40% of students obtaining full marks. Common errors were that some students:

- failed to calculate the total activity;
- incorrectly used proportion to calculate the liberty of each isotope
- attempted to calculate the number of atoms of each isotope, and the decay constant of each isotope and then to calculate the activity from first principles. This approach clearly took a long time and only very seldom met with limited success.

(ii) Similarly this part was well done with a significant proportion of students calculating the activities of both uranium-234 and uranium-238. Very few students realised that the activity of uranium-2 38 remains approximately constant over 1.0 x 10^6 years, because this time represents less than 1/1000 of a single half life of uranium-238.

(b) (i) About 60% of students obtained full marks for this question with the commonest error being the omission of units.

(ii) Again this was well done the commonest areas being the omission of units again, and failure to pay attention to the number of significant figures.

(iii) Most students correctly quoted the use of Kepler's Third Law either directly or indirectly, but confused themselves by talking about the present, when the question explicitly asked about the length of a month in the past.

Question 6

(a) Unfortunately most students calculated and quoted the angle of incidence as the answer while failing to follow the explicit instruction which asked for the angle between the glass-liquid interface and the incident ray.

(b) (i) This question well done with most students at least correctly using the Young's double slit equation. Sadly there seemed to be some difficulty with the algebra involved.

(ii) A significant number of students calculated the two wavelengths and subtracted them correctly, and quoted the answer in metres instead of confining themselves to a whole number of wavelengths.

(c) (i) This question was well done, with about 70% of students calculating the speed of light in plastic correctly.

(ii) For some reason a significant number of students became tangled up with calculating frequencies which turned out to be constant, and then using these to calculate the wavelength.

(iii) Again this was well done, with most students dividing the given distance by the given wavelength. A common error was to give the answer as 30 metres, rather than just as a whole number.

(d) (i) This question was badly done, with only about 20% of students calculating the path difference correctly.

(ii) Most students attempted this bonus marks section, with what appeared to be sheer guesswork. Since the path difference was a whole number of wavelengths, the positions of the fringes would not be altered because the plastic sheet alters the wavelength of one of the light rays before it passes through the slit. Some marks were given for a consideration of the intensity of the fringe pattern due to some absorbance of light by the plastic.

Question 7

(a) Done well by most but most did not give a direction. Common mistakes: E was calculated instead of F, the changes were used as land 2 not 1.6×10^{-19} and 3.2×10^{-19}, $Q_1 \times Q_2$ was interpreted as Q_3.

(b) (i) Well done.

(ii) Generally well done.

(iii) Done well apart from many candidates not squaring the velocity as they had correctly written in their formula.

(c) (i) Well done.

(ii) Many proved $V = \frac{E}{B}$ instead of substituting $V = \frac{E}{B}$ into the $F_B = Bqv$ formula to show it simplified to Eq.

(iii) Many methods used to validate the answer but generally well done.

(iv) Most just quoted the formula $\frac{m}{q} = \frac{BR}{V}$ to get a correct answer. Common mistakes were to leave off the units or to calculate $\frac{q}{m}$.

Question 8

(a) (i) One candidate actually knew the convention that when the multiplier is written after the unit that it means that the number on the axis has been multiplied by the multiplier to get the axis value, therefore, the true value is the axis value divided by the multiplier. About 10% of candidates change multiplier to x 10^{-14} and 10^{14} and got the correct answer. Most knew the gradient and were given full marks if they used the correct method with the wrong multiplier.

(ii) Candidates regularly got 4×10^{19}J because of the unit problem. Despite being the total energy release of several nuclear devices candidates were given full marks if their method as correct.

(iii) Well done.

(b) (i) Good but some failed to calculate f or give a formula. Note E = h x P give the correct number but is still incorrect.

(ii) Many failed to show a method.

(iii) Well done.

(iv) Poorly done if attempted by < 10% got more than half a mark with only a few people getting full marks, Only 2 candidates explained use of momentum and NIII.

Question 9

(a) Generally well answered although the drawing of the electric field lines was poor.

(b) Surprisingly badly answered. Only about one in four students understood the idea of charge being quantised. Many students simply worked out the average value of the results and several students simply added the six numbers (with signs) to get the correct answer of 2 ($\times 10^{-19}$)!

(c) Most students gained some marks for this part of the question. There was some confusion between emission and absorption spectra but generally well done.

(d) Most students knew that electrons were demonstrating wave properties. Not many mentioned the diffraction of the electrons. There was some confusion about why the pattern would not be seen using Young's experiment slits with quite a few students saying that the electrons were too big to go through the slits. Not many students mentioned that the "wavelength" of the electrons was very small and any diffracting device needed to have spacings of a similar size.

Question 10

(a) Part (i) was generally well answered and most students gained at least reasonable marks in part (ii). In part (iii) many students discussed changes in magnetic *field* or *current* rather than force. Many students had the force reversing direction as the ring passed the half way mark so that it left the coil with increased velocity. Bonus marks were allocated to students who gave a complete and accurate description of the whole motion.

(b) Part (i) was well answered, while part (ii) was reasonably well answered. However, a surprisingly large number of students had the light bending the wrong way. In part (iii) full marks were given to answers that included critical angle calculations, while bonus marks were given to the few students who managed to fully understand the principle of this type of refractometer.

(c) (i) The diagram was not a scale diagram of the velocities of each of the particles and so any attempt to try to find the momentum of each piece led to the result that momentum was not conserved.

However most candidates obtained full marks by stating that they expected momentum to be conserved and by drawing a closed vector triangle of momentums.

The kinetic energy part was very poorly answered, most candidates did not realise that energy will be released as a result of the nuclear reaction that was taking place. Typically candidates said (incorrectly) that this was an elastic collision or that perhaps energy was lost as heat or sound, etc.

(ii) Part one of this question was well done. Part 2: Almost all candidates knew that there had been a decrease of energy of scattered photon but many were then not able to deduce that this corresponds to an increased wavelength. A bad mistake was to have scattered photon travelling slower and hence a shorter wavelength. Part 3 was well done by most.

(d) (i) Only about half of the candidates correctly balanced both equations.

(ii) The fact that enriched uranium contains a larger percentage of ^{235}U which splits to produce 3 neutrons which can initiate further reactions makes a chain reaction more likely in the enriched uranium.

(iii) Well done.

(iv) Too many candidates thought that by forming a compound, the uranium become more stable and therefore not radioactive. This must be the view that is commonly accepted in the community.

Perhaps 15% of candidates indicated that □,*B*,□ radiation was also radioactive and could contaminate the soil in some way.

Many candidates listed the hazards of radioactive material but this was not part of the question.

Question 11

(a) (i) Many students did not draw a triangle showing the three vectors. The instruction was quite specific. Of those who constructed triangles, at least one vector was often given the wrong direction giving a vector sum that did not combine to zero.

(ii) This was often well argued regardless of whether part i. was completed satisfactorily. A few answers demonstrated a poor understanding of the Physics of these situations.

(b) (i) Generally well answered. A common error was to have different thrust vectors across the three situations. Another was to show a frictional resistance force when the jet-boat had zero velocity.

(ii) The majority of students picked this as Newton's Third Law (or conservation of momentum). Answers were generally good, but occasional misunderstandings showed through.

(c) A significant number of students used the given information to correctly answer the question, however many un-necessarily relied on the old standby of friction, light, heat and sound.

(d) (i) Most students successfully read the graphs and gave the correct answers, however a few had problems with units. A small number tried to calculate the answers using a remarkable array of formulae, many of which do not stand up to scrutiny.

(ii) The majority were aware of the concept of beats and answered appropriately. Of those, many did not use the graph to give the beat frequency, but launched off into complex calculations based, in many cases on an incorrect usage of the difference between the periods in part i., rather than on the difference in frequencies.

(e) (i) Generally well answered.

(ii) A large proportion of candidates did not comment on the overall effect of the two waves, but rather commented on the two situations shown in part i. Those who picked the question correctly described standing waves adequately.

(f) (i) Mostly answered correctly. A substantial number of students did not answer this question – perhaps they did not see it?

(ii) Diagrams and descriptions were generally quite good showing that students are very visual in their understanding of standing waves.

(iii) Not answered particularly well. Students often resorted to restating the question or using related key words such as resonance, constructive, destructive interference or throwing in formulae that proved the conjecture. The answers showed that only a handful of students have any sort of deep understanding of the events that lead to the production of standing waves.

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Physics C Solutions November 2003

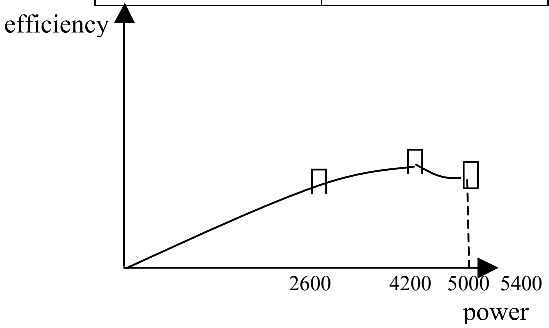
Question 1

a) Total energy equals area under power~time graph.
Energy produced = 900□(120+20)+900(20+20)+_900(40) = **180000kWh**

b) average power output = 180000/160 = **1125kW**

c)

2600	4200	5400	5000
0·346	0·429	0·000	0·36



The graph need only be a sketch – enter the two points given and another when wind power is a maximum (5400) and when power output drops to zero (estimated at about 5000) – the point (0,0) is another that can be included.

d) Firstly, efficiency reduces for wind power greater than 4200kW. Secondly for wind power greater than 5000kW, the efficiency drops to zero. These may be protection features incorporated into the design so that for strong winds the power output drops (to ensure that the turbine does not overheat?) but the wind generator shuts down completely for gale-force winds (to protect the mechanical aspects of the generator?)

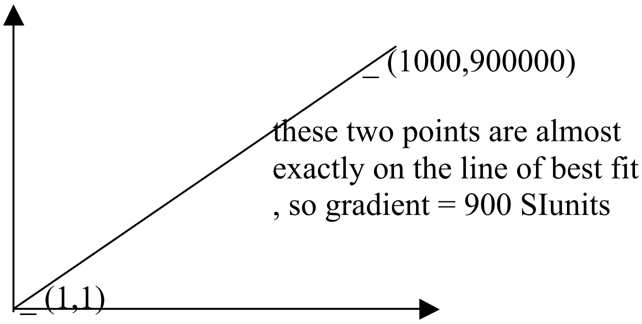
Question 2

a) The graph seems to stray from the cubic function at about 10m/s. (it straightens)

b)

	1	3	4	6	8	9	10
kW	1	24	56	189	450	640	900
v^3	1	27	64	216	512	729	1000

c)

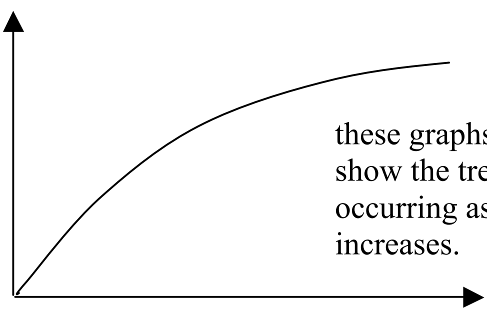


d) Using this gradient, c_p = gradient/□A = 900/1_225/3420 = **0_215.** Efficiency is 0·215 or 21·5%.

Question 3

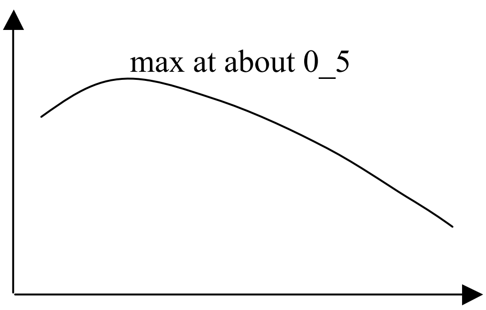
a) Gradient appears to be about 15/20 = 0_75ms^{-2}.

b)



these graphs need only show the trend that is occurring as nozzle size increases.

c)



d) A compromise between manoeuvrability and top speed would see a choice of nozzle size a little larger than 0·5m, but less than 0·8m, as all diameters from 0·2 to 0·8 have about the same top speed, however larger diameters give better manoeuvrability. The choice is really up to the principle usage of the boat, say 0·7 for a good all-round vessel.

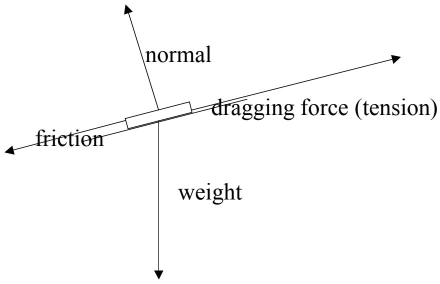
Question 4

a) i. gravitational force = weight = mg = $1000 \times 9{\cdot}8$ = **9800N ("down")**

ii. component of W parallel to slope = $mg\sin\theta = 1000 \times 9{\cdot}8 \times \sin 5^{\circ} = 854{\cdot}13$N
component = **854N**, "down the slope".

iii. if rock is travelling at constant speed, dragging force just balances the friction plus component of weight,
so friction = drag – component of weight = (2000 – 854) = **1146N**

iv.



b) i. Using force = rate of change of momentum, in one second
momentum change of water = mass of water × change in velocity
$= 1 \times 10^4 \times 32 = 3{\cdot}2 \times 10^5$ kgms^{-1}.
$F = \Delta p/t = 3{\cdot}2 \times 10^5 \div 1$ = **$3{\cdot}2 \times 10^5$N**

ii. KE of water emerging in each second = $\frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times 10^4 \times 32^2$ = **5120000Js^{-1}**.

iii. Since power = $\Delta E/t$, the engine must expel the water faster so that the smaller mass has the same KE. Since the mass of water expelled each second is halved, the square of its velocity must double, hence its new expulsion speed is $\sqrt{2} \times 3{\cdot}2 = 4{\cdot}53$ms^{-1}
Since force = rate of change of momentum, the new force is $\frac{1}{2} \times \sqrt{2} \times 3{\cdot}2 \times 10^5$ =
$2{\cdot}26 \times 10^5$N

iv. *Should be parts i. and iii. as quantities for comparison must have same units.* Although the second scenario produces the same power as the first, since power = $F \times v_{av}$, its effective propulsive force is less because the velocity of the expelled water is not as great in proportion as the decrease in mass of expelled water.

Question 5

a) i.

	Natural uranium	Depleted uranium
Activity of U238 (Bq)	**$1{\cdot}23 \times 10^7$**	$1{\cdot}24 \times 10^7$
Activity of U234 (Bq)	**$1{\cdot}26 \times 10^7$**	$1{\cdot}9 \times 10^6$
Total activity (Bq)	**$2{\cdot}49 \times 10^7$**	$1{\cdot}43 \times 10^7$

Calculations: A (U238) = $1{\cdot}24 \times 10^7 \times (2{\cdot}51/2{\cdot}53) = 1{\cdot}23019 \times 10^7$.
A (U234) = $1{\cdot}9 \times 10^7 \times (1{\cdot}39 \times 10/2{\cdot}1) = 1{\cdot}2576 \times 10^7$.
Total = $1{\cdot}23 \times 10^7 + 1{\cdot}26 \times 10^7 = 2{\cdot}49 \times 10^7$.

ii. After 1×10^6 years, total activity will depend principally on the U238 since 10^6 years is less than 1/1000th of a half life for U238, but is about 4 half-lives for U234.
Total activity = $1{\cdot}9 \times 10^6(\frac{1}{2})^{(10 \div 2{\cdot}45)} + 1{\cdot}23 \times 10^7 = 1{\cdot}122 \times 10^5 + 1{\cdot}23 \times 10^7$ = **$1{\cdot}24 \times 10^7$Bq**, assuming that the U238 activity has not changed.

b) i. Using $g = GM/d^2$, we get $GM = gd^2 = 9{\cdot}80665 \times (6{\cdot}3754 \times 10^6)^2$ = **$3{\cdot}9859 \times 10^{14}$m^{3}s^{-2}.**

ii. Using Kepler's third law $T^2 = 4\pi^2 r^3/GM$, so
$T = \sqrt[2]{[(4\pi^2(3{\cdot}8440 \times 10^8)^3/(3{\cdot}986 \times 10^{14})]}$ = **$2{\cdot}3718 \times 10^6$s**

iii. Since T^2 is proportional to r^3, both will increase together. If the radius of orbit increases, so does the period. Hence the period was shorter before and so a 'month' was shorter in the past.

Question 6

a) Using Snell's law, $N_1\sin\theta_1 = N_2\sin\theta_2$, $1{\cdot}75\sin(90-\theta) = 1{\cdot}5\sin 90$. $\theta = \arccos(1{\cdot}5 \div 1{\cdot}75)$ = **31°**

b) i. Using $\lambda/d = W/X$, we get $W = 5 \times 10^{-7} \times 2 \div 0{\cdot}01$ = **0·0001m**

ii. 3rd bright fringe corresponds to the 3rd occurrence of p.d. $= n\lambda = 3\lambda$ (**3 wavelengths**).

c) i. Using n = speed in vacuum ÷ speed in medium, speed = $3 \times 10^8 \div 1{\cdot}5$ = **2×10^8ms^{-1}**.

ii. Using $v = \lambda f$, so $f = v_1/\lambda_1 = v_2/\lambda_2$ and $\lambda_2 = \lambda_1/n$, $\lambda = 5\times10^{-7} \div 1{\cdot}5 =$ **$3{\cdot}33333\times10^{-7}$m**

iii. Number of complete waves = thickness/λ = $1\times10^{-5}\div3{\cdot}33\times10^{-7}$ = **30**

d) i. The plastic region would normally have 20 wavelengths across it, but when present 30 wavelengths would exist. Hence 10 extra wavelengths have been introduced by using the plastic, so p.d. = 10λ.

ii. The fringe pattern will shift, assuming there is no phase change on entry or exit with the plastic. The central bright fringe (p.d. = 0) will now be away from the centre of the apparatus, on the same side as the plastic.

Question 7

a) Using Coulomb's Law, $F = kQq/d^2 = (9\times10^{9})\times(2\times1{\cdot}6\times10^{-19})\times(1{\cdot}6\times10^{-19})\div(4\times10^{-10})^2$

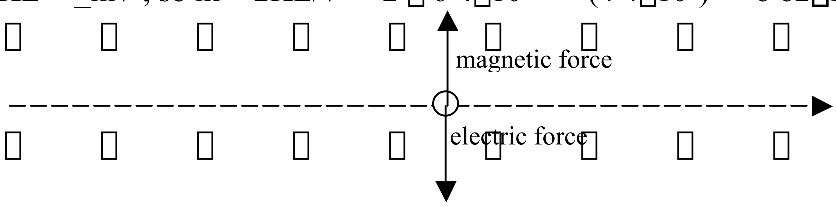
$= \mathbf{2{\cdot}88\times10^{-9}N}$

b) i. Using $v = s/t$, speed = $1\div 2{\cdot}275\times10{-}6 = 4{\cdot}3956\times10^{5}$ = **$4{\cdot}40\times10^{5}$ms^{-1}**.

ii. $KE = \Delta KE = \Delta E = W = qV = 2\times1{\cdot}6\times10^{-19} \times 2\times10^{4}$ = **$6{\cdot}4\times10^{-15}$J**

iii. $KE = \frac{1}{2}mv^2$, so $m = 2KE/v^2 = 2 \times 6{\cdot}4\times10^{-15} \div (4{\cdot}4\times10^{5})^2$ = **$6{\cdot}62\times10^{-26}$kg**

c) i.



ii. $F_E = qE$, $F_B = qvB\sin\theta$. When E, B and v are mutually perpendicular as in the diagram, the two forces will add to zero (equal and opposite) when $F = qE = qvB$. Hence the velocity of the ion has magnitude given by $E = vB$ or **$v = E/B$**.

iii. Using $E = V/d$, $E = 289{\cdot}7/0{\cdot}02 = 14485$NC^{-1}. If the ions are to have no nett force then their velocity must be given by $v = E/B = 14485/0{\cdot}1 = 144850$ = **$1{\cdot}449\times10^{5}$ms^{-1}**.

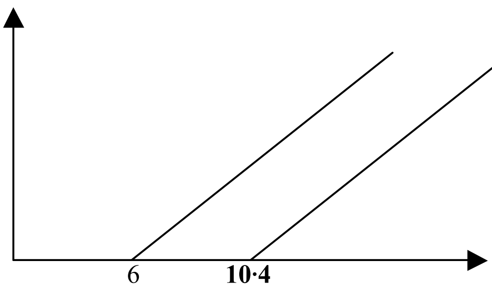
iv. Using $r = mv\sin\theta/qB$, if a circular path is to be formed, then $\theta = 90^{\circ}$, so $m/q = rB/v = 0{\cdot}3 \times 0{\cdot}1 \div 1{\cdot}449\times10^{5}$ = **$2{\cdot}07\times10^{-7}$kgC^{-1}**.

Question 8

a) i. Using the points (6,0) and (18,8) which the graph seems to pass through, the gradient of the graph is 8/12 = 0·666 units. The vertical axis has been multiplied by 10^{19} and the horizontal by 10^{-14} to obtain the values listed on the axes. The gradient of the relationship between E and f is therefore $0{\cdot}666\times10^{-14}/10^{19} = 6{\cdot}66\times10^{-34}$Js. The graph represents Einstein's photoelectric equation $KE_{max} = hf - W$, so Planck's constant evaluates to h = **$6{\cdot}66\times10^{-34}$Js**.

ii. The work function for sodium is the intercept on the energy axis, also given by hf_0, where f_0 is the threshold frequency, so $W = 6{\cdot}66\times10^{-34} \times 6\times10^{14}$ = **4×10^{-19}J**.

iii.



The new graph is parallel to the one given, but with a different threshold frequency.

b) i. Using $E = hf = hc/\lambda = 6{\cdot}63\times10^{-34} \times 3\times10^{8} \div 0{\cdot}03$ = **$6{\cdot}63\times10^{-24}$J**.

ii. If the beam has a power of 10^{10}W, then it delivers 10^{10}J per second. The number of photons per second is $(10^{10})\div(6\times10^{-24})$ = **$1{\cdot}508\times10^{33}$ s^{-1}**

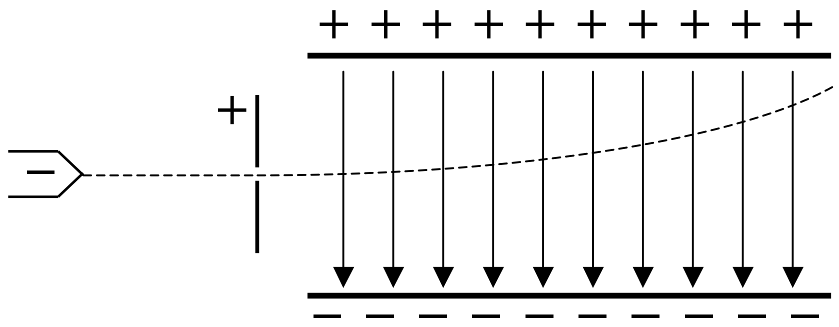
iii. According to Compton (originally suggested by Einstein) $p = h/\lambda = 6{\cdot}63\times10^{-34}\div0{\cdot}03$ = **$2{\cdot}21\times10^{-32}$kgms^{-1}**.

iv. Using a = F/m = rate of change of momentum of photons/mass of probe, we get

$a = 2\times2{\cdot}21\times10^{-32}\times1{\cdot}51\times10^{33}/1/0{\cdot}020$ = **$3337{\cdot}1$ms^{-2}**.

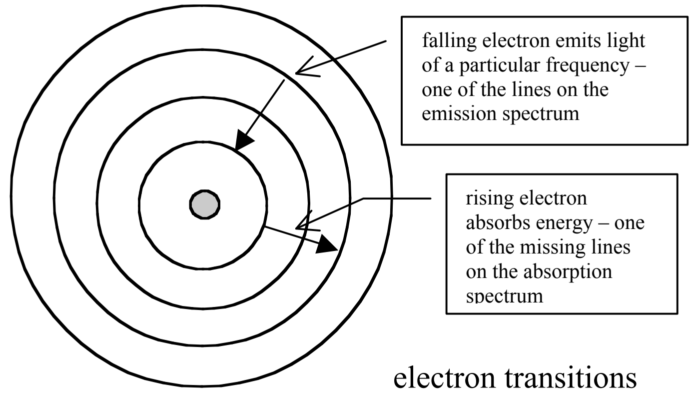
Question 9

a)



b) The most likely value is $-2{\cdot}0\times10^{-19}$C. Because charge is quantised, the smallest charge must be able to accumulate to give any of the values listed – it must be a factor of each value listed. Since 2·0 is the highest common factor of +6, +8, –4, –10, +8 and –6, it can be assumed to represent the smallest quantum of charge, that is $-2{\cdot}0\times10^{-19}$C for the negative electron.

c) When hydrogen gas is excited by heating or by electric discharge it emits light in the visible, and near-visible regions of the electro-magnetic spectrum. Analysis of the emitted light (the line emission spectrum) shows that only certain distinct wavelengths of radiation are emitted. These wavelengths correspond to specific energy values that exhibit additive relationships with one another, suggesting that a hydrogen atom de-excites after initial stimulation and emits an amount of radiation energy that corresponds to its own loss of energy. Since a hydrogen atom is composed of only one electron, it was supposed that electron energy levels existed within the hydrogen atom and transitions from one level to another corresponded to discrete energy values. Experiments with other elements exhibited similar patterns of line emission spectra.



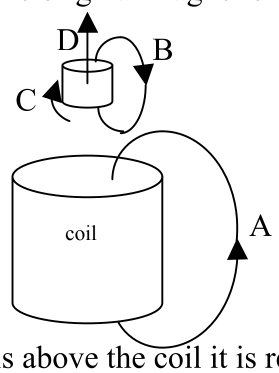
electron transitions correspond to emission or absorption of light with wavelengths that are characteristic of hydrogen.

d) This suggests that electrons have a property similar to a wave property, namely interference. In the Young's Double Slit Experiment the width of the fringes (W) depends on the ratio of wavelength to slit separation (λ/d) for any given screen distance (X). If d for electron interference is of the order of d for light interference, to get the same interference fringes the "wavelength" of the electrons would need to be of micrometre dimension (vis light averages 500nm, or 0·5μm). Since electrons are parts of atoms it is unlikely that their wavelength would exceed the dimensions of an atom (10^{-12}m), so the width of the fringes would be extremely small and not therefore detectable.

Question 10

a) i. Lenz' Law states that an induced current will have an effect that opposes the change that caused it. If a conductor moves through a magnetic field in such a way that a current is induced in it, then the conductor will have a magnetic field (due to the induced current) that pushes on the original magnetic field, tending to slow the moving conductor.

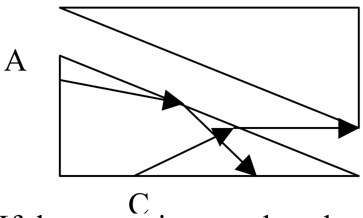
ii.



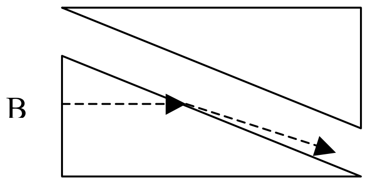
iii. When the ring is above the coil it is repelled (opposing its motion into the coil), when inside the coil there is no force (moving parallel to a uniform field – no induced current), and when below the coil the force is attracting the ring upwards. The force is up all the time, whenever it exists.

b) i. Total internal reflection occurs when a wave passes from one medium to another and speeds up, that is, it passes from a medium with higher refractive index to one of lower refractive index The wave will be refracted and bend away from the normal. If it bends so far that it cannot travel in the second medium it remains within the first medium and has been totally internally reflected.

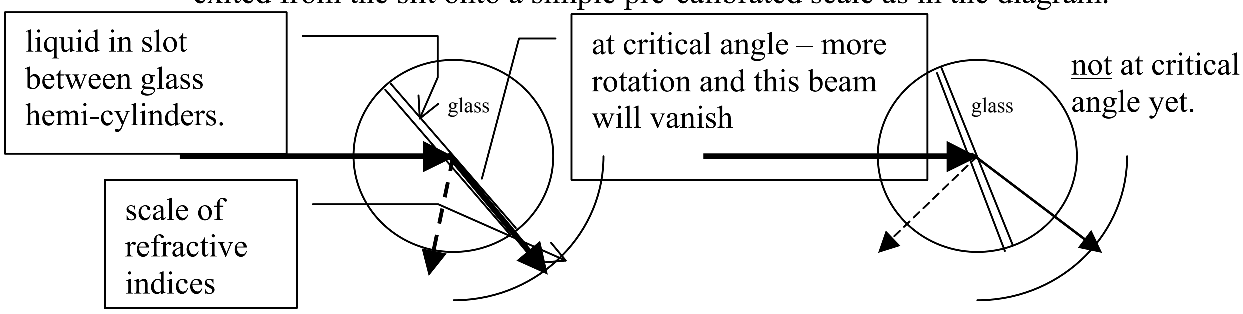
ii.



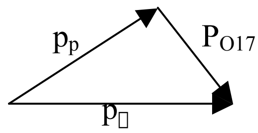
iii.



iv. If the two prisms and enclosed slot could be rotated with respect to the incident beam a simple refractometer would have been made. Rotate the apparatus until the light strongly exited from the slit onto a simple pre-calibrated scale as in the diagram.

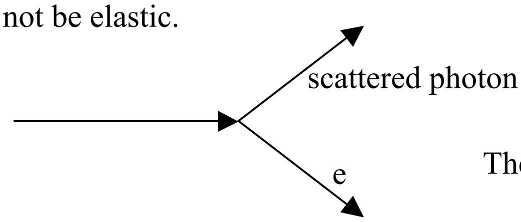


c) i. Momentum will be conserved in this collision.



Kinetic energy will not be conserved as nuclear energy will released – the collision will not be elastic.

ii.



The Law of Conservation of Momentum.

The scattered photon will have a longer wavelength.
The energy of the incoming photon would equal the sum of energies of the scattered photon and the electron.

d) i. ${}_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239}$.
${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{38}Sr^{90} + {}_{54}Xe^{143} + 3\,{}_{0}n^{1}$.

ii. because U235 emits more neutrons when it is struck by a neutron, the process will be self perpetuating provided there is a strong probability that at least one of the released neutrons strikes another U235. Enriching natural uranium so that it contains proportionately more U235 will tend to improve the chances of subsequent collisions, so enriched uranium is better able to maintain a fission reaction.

iii. 2 alpha particles (step 1 and 4) and two beta particles (step 2 and 3) are emitted in the transformation of a single atom of U238 to Th230.

iv. Uranium compounds are still radioactive – it is the nucleus of atoms that determines their radioactivity and not any chemical changes that may occur.

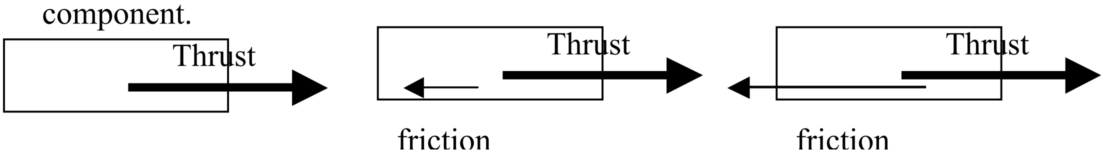
Question 11

a) i.

W must be the same in both triangles

ii. A stronger cable is required for the smaller angle since the tension force is much greater. This is because the vertical component of tension must equal the weight of the bridge. The further tension is from the vertical, the longer it needs to be to have the same vertical component.

b) i.



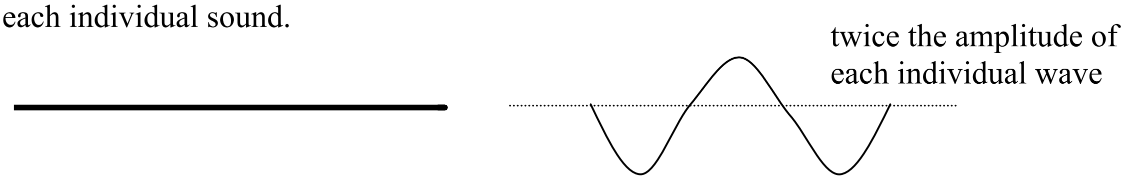
ii. The water needs to be pushed out the back of the boat by a force exerted from the boat. According to Newton's Third law this "action" must be accompanied by a "reaction" – a force from the water pushing on the boat.

c) If all the kinetic energy of the wind was converted into useful energy then the air would not be moving after the turbine. It could therefore not get away from the wind turbine to allow other air to enter. It must have a small velocity and hence some KE to get away.

d) i. Wave A has period 20ms, wave B has period 22ms.

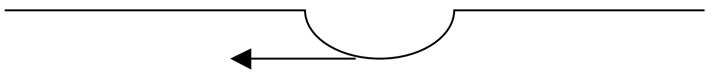
ii. An observer will hear a sound that increases and decreases in loudness. The "period" of this effect is 200ms. At maximum loudness, the sound heard has twice the amplitude of each individual sound.

e) i.

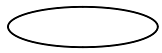


ii. A standing wave will be produced. It does not travel in either direction (it is stationary). Loops of string between stationary points (nodes) oscillate up and down with the same frequency as the original waves. The points midway between each pair of nodes (antinodes) have the greatest amplitude of vibration and the amplitude of the other points varies according to their position on the string.

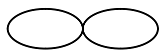
f) i. The pulse will be horizontally reversed and vertically reversed (upturned)



ii. The string could vibrate at its fundamental frequency.
(first harmonic)



The string could vibrate at its first overtone.
(second harmonic)



The string could vibrate at its third overtone.
(fourth harmonic)

iii. Although nodes are established at each end of a vibrating string, the nodes from one end do not align with nodes from the other end unless the two ends are a whole number of half wavelengths apart. It is only when the nodes align that a standing wave is formed. The speed of the wave is the same for all frequencies, but the wavelength varies as frequency is changed, so most frequencies do not form standing waves, it is only those that correspond to an aligning of nodes that do.