T A S M A N I A N

S E C O N D A R Y

A S S E S S M E N T

B O A R D

PH866

Physics

1999 External Examination Report

General Comments

There were some slight modifications to the exam format including Sections A and B being presented in a separate booklet from Section C. This format certainly led to more efficient marking, however feedback via teachers would be appreciated at the moderation meetings during the coming year as to how this format was accepted by candidates.

Because of the change in emphasis in Section A, the exam questions closely paralleled the sample questions distributed during the year. This modified method of assessing Criterion 7 will be further discussed at upcoming moderation meetings.

In the marking process, points allocated by the markers closely followed the suggested time allocations in minutes. Minimum points for the various ratings in Criteria 7, 9 and 10 were as follows.

	Crit 7	Crit 9	Crit 10
Total Points	45	60	75
A rating	27	43	46
B rating	30	31	36
C rating	20	21	27

Criterion 2 was assessed by each marker and an overall award achieved by an averaging process. The marking panel was generally happy with the exam paper as a discriminator. There seemed to be a good balance between harder and easier questions, with the possible exception of Question 10 (c) (ii) which proved too difficult for candidates.

Thanks are extended to the 12 markers who completed the marking task in an efficient and co-operative manner.

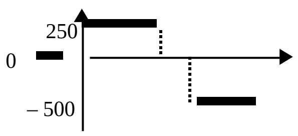
Section A

Question 1

(a)

(i) The gradient of each line is a measure of the force acting on the car: F = gradient = 250N

(ii)

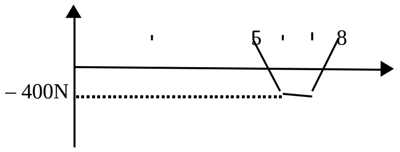


(b)

(i) The area between the graph and the time axis represents change in momentum. For the first three seconds, Δp = area = 800 "units" = 800kgms^{-1}.

(ii) Between 0 and 8 seconds Δp = 800 – 300 = 500kgms^{-1}.

(iii) The area "above" the graph between 5 and 8 seconds must be changed to 800 "units", one example could be:



(c) Acceleration (dependent variable) should be plotted vertically against the force (independent variable) on the horizontal axis, because it is expected that since acceleration is proportional to resultant force (a = F/m), a linear relationship exists between a and applied force (resultant force + a component to overcome friction).

Comments

Success in this question was closely linked to the understanding of applying of calculus concepts to physics.

Those that realised that:

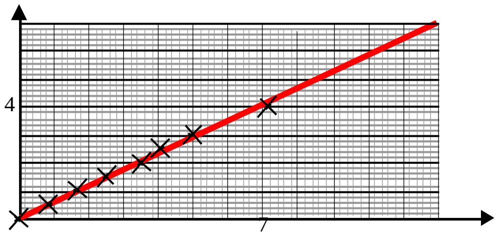
- slope of momentum - time graph = unbalanced force applied; and
- area under force – time graph = change in momentum;

did extremely well. Many candidates showed skill in applying these concepts succeeding in the question.

Question 2

Modify data to plot a s~t^2 graph.

s	0	0·50	1·00	1·50	2·00	2·50	3·00	4·00
t^2	0	0·83	1·64	2·46	3·50	4·08	4·93	7·18

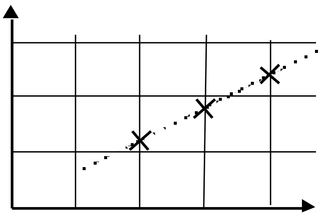


(b) The gradient (slope) of this graph is approximately 7/12, that is 0·583. Because s = _at^2, and s has been plotted against t^2, the gradient is a measure of _a. Acceleration is therefore given by:- a = 2 x slope = 1·17ms^{-2}.

(c) Careful drawing of tangents on the given graph at t = 1, 1·5 and 2 seconds should yield values for "slope" *close to* 1·265, 1·778 and 2·424 "units". The technique that you use will involve dividing a "rise" by a "run". The "rise" and "run" are determined by marking any two points on the drawn tangent and determining their "co-ordinates". These are used to find "rise" and "run" in the usual manner.

(d) Using the values of instantaneous velocity determined by the slope of the three tangents (1·265ms^{-1} at 1·0 s, 1·778ms^{-1} at 1·5s and 2·424ms^{-1} at 2·0s) a sketch graph like this is obtained:-

The slope of this line is constant and determines acceleration at 1·16ms^{-2}, a little less than the result in b).



Comments

The question was based around the very familiar situation of motion under simple acceleration and targeted two methods of increasing the acceleration from displacement time data.

Candidate familiarity was demonstrated by a high success rate for both approaches in the question.

The first approach to achieving the acceleration was based around the $s \sim t^2$ graph. It should be noted that the questions are designed to lead candidates along the ‘conventional’ approach. Those who had achieved mastery in this approach did well.

The second approach based around drawing tangents and measuring slopes also demonstrated candidate confidence. Many candidates achieved satisfactory values of the acceleration. Some commented on the nearness of the time values.

Section B

Question 3

(a)

(i) Resultant force on car = 2 x 400 – 100 = 700N
acceleration = F/m = 700/1200 = 0·583ms^{-2}.
$v^2 = u^2 + 2as$, $s = 4^2 \div (2 \times 0{\cdot}583) = 13{\cdot}7$m

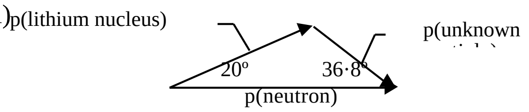
(ii) energy change = increase in KE = _mv^2
= 0·5 x 1200 x 4^2 = 9600J

(iii) total work = force x distance = 800 x 13·7 = 10960J

(iv) average power = work done / time
= force x average velocity
= 800 x 2 = 1600W
{ alt: time = (v – u)/a = 4/0·583 = 6·86s ;
P = W/t = 10960/6·86 = 1597·66J}

(b)

(i)



(ii) The "vertical" component of each momentum after the collision must have the same size (and opposite directions).
$m_1 v_1 \sin 20° = m_2 v_2 \sin 36{\cdot}8°$

Since each particle has the same speed ($v_1 = v_2$)
Mass = 7 x sin20/sin36·8 = 4

uestion 4

(a)
(i) $g = GM/d^2$
$= 6{\cdot}67 \times 10^{-11} \times 5{\cdot}98 \times 10^{24}/(6780 \times 10^3)^2$
$= 8{\cdot}68\text{Nkg}^{-1} = 8{\cdot}68\text{ms}^{-2}$ down.

(ii) orbital speed, $v = \sqrt{\frac{GM}{r}}$, {from $GM\not{m}/r^{\not{2}} = \not{m}v^2/\not{r}$}
$= [6{\cdot}67 \times 10^{-11} \times 5{\cdot}98 \times 10^{24}/(6780 \times 10^3)]^{0{\cdot}5}$
$= 7670\text{ms}^{-1}$.

(b)
(i) $\varepsilon = v\ell B\sin\theta = 7670 \times 20 \times 10^3 \times 2 \times 10^{-5} \times \sin 90^\circ = 3070\text{V} = 3{\cdot}07 \times 10^3\text{V} = 3{\cdot}07\text{kV}$.

(ii) $P = VI = 3{\cdot}07 \times 10^3 \times 0{\cdot}6 = 1840\text{W}$.

(iii) $F = Bi\ell\sin\theta = 2 \times 10^{-5} \times 0{\cdot}6 \times 20 \times 10^3 \times \sin 90^\circ$
$= 0{\cdot}24\text{N}$

The force, using "Lenz' Law", opposes the action that induced the emf responsible for the current, that is the motion of the "tether". The force will be to the right in the diagram.

Comments

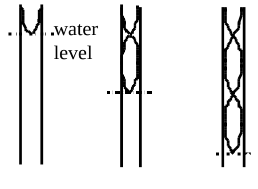
Attempted by nearly all candidates with a generally high degree of success.

In the ‘show’ questions, many candidates did not show the working to get from the appropriate formula to the given answer. Some candidates had lots of wrong working that somehow magically gave the correct ‘given’ answer on the last line (no marks).

Question 5

(a)
(i)

(ii) The change in length is 0·500 – 0·166 = 0·334 in one part and 0·833 – 0·500 = 0·333 in the other. These are measures of the "internodal distance" of the standing wave pattern established (by resonance) in the "closed" air column. That is, half a wavelength = 0·3335. $\lambda = 0{\cdot}667$m.



Speed of sound, $v = \lambda f$
$= 0{\cdot}667 \times 512 = 341{\cdot}5\text{ms}^{-1}$.

(b)

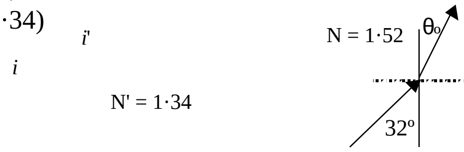
(i) $N = v_1/v_2$, $v = 3 \times 10^8 \div 1{\cdot}52 = 1{\cdot}97 \times 10^8 ms^{-1}$.

(ii) Snell's Law, $N\sin i = N'\sin i'$,

$i' = \sin^{-1}(\sin 58^o \times 1{\cdot}52 \div 1{\cdot}34)$

$= 74{\cdot}1^o$

Hence $\theta \approx 16^o$



(iii) "critical angle" = $\sin^{-1}(N'/N)$

$= \sin^{-1}(1{\cdot}34/1{\cdot}52) = 61{\cdot}8^o$

Hence *minimum* $\theta = 28{\cdot}2^o$

Comments

(a) (i) Candidates who drew correct wave forms generally calculated correct speed.

(ii) A significant number of candidates used incorrect equation, rather than determining wavelength from 1st principles and then using wave equation ($V = f\lambda$)

(b) (i) A significant number thought speed of light unchanged in glass or actually increased.

(ii) Common error was assuming 32˚ was the angle of incidence rather than (90-32)˚.

(iii) Maximum angle between light beam and wall = $(90 - i_1)$

Question 6

(a)

(i) $I = q/t = 200/(200 \times 10^{-6}) = 1 \times 10^6 A$

(ii) $P=VI = 1 \times 10^9 \times 1 \times 10^6 = 1 \times 10^{15} W$

(iii) $E = V/d$ $d = V/E = 1 \times 10^9/(3 \times 10^6) = 333m$

(iv) Inwards, since parallel currents attract.

(v) Amperes Law $F = kIi\ell/d = 2 \times 10^{-7} \times 5 \times 10^5 \times 5 \times 10^5 \times 10/(1{\cdot}0 \times 10^{-2}) = 5 \times 10^7 N$

(b)

(i) energy = $qV = 200 \times 1 \times 10^8 = 2 \times 10^{10} J$

(ii) temp rise = energy ÷ (mass x 3000)

$= 2 \times 10^{10} \div (6{\cdot}4 \times 10^3 \times 3000)$

= 1040ºC or 1040K.

Question 7

(a)

(i) $p = h/\lambda = 6{\cdot}63 \times 10^{-34}/(5 \times 10^{-7})$
$= 1{\cdot}33 \times 10^{-27}\text{kgms}^{-1}$
total momentum $= 2{\cdot}5 \times 10^{23} \times 1{\cdot}33 \times 10^{-27}$.
$= 3{\cdot}3 \times 10^{-4}\text{kgms}^{-1}$.

(ii) force = rate of change of momentum $= 2 \times 3{\cdot}3 \times 10^{-4}\text{kgms}^{-1}/\text{s} = 6{\cdot}6 \times 10^{-4}\text{N}$

(b)

(i) $\lambda = 0{\cdot}693/T_{\_} = 0{\cdot}693/30{\cdot}2 = 0{\cdot}0229\text{yr}^{-1}(7{\cdot}27 \times 10^{-10}\text{s}^{-1})$
no. of atoms $= 100 \times 10^{-3} \div (2{\cdot}27 \times 10^{-25})$
$= 4{\cdot}41 \times 10^{23}$.

In SI units!, $A = \lambda N = (0{\cdot}693/(9{\cdot}53 \times 10^{8}) \times 4{\cdot}41 \times 10^{23}$.
$= 3{\cdot}21 \times 10^{14}\text{Bq}$

(ii) $A/A_0 = 1 \times 10^{4}/(3{\cdot}21 \times 10^{14}) = 3{\cdot}12 \times 10^{-11}$.

No. _-lives = $\log(3{\cdot}12 \times 10^{-11})/\log(\_) = 34{\cdot}9$

Hence it would take 1050yrs (= $30{\cdot}2 \times 34{\cdot}9$) ($3{\cdot}33 \times 10^{10}$s).

Comments

Overall, this question was reasonably well answered. About one in ten people did not attempt this question and this may be due to poor time management – being the last question of the booklet. Not expressing units to answers was a very common problem.

Section C

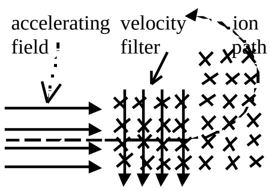
Question 8

(a) Measure the gravitational force on a known mass, and then calculate gravitational field strength using:- $g = F/m$

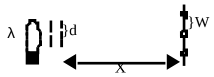
(b) Mass spectrometers use electric fields to accelerate ions. The high speed ion is then deflected using a magnetic field, in which the ion has a circular path. The radius of the circular path is then used to determine the characteristics of the ion, particularly its "charge to mass ratio" using the equation:- $q/m = v/rB$

If the speed and charge of the ion are known, its mass can be determined. A "velocity filter" is sometimes used to determine (or set) the velocity of ions.

[A diagram, of one of the many types of mass-spectrometer, would be appropriate to illustrate your answer]



(c) Light passing through a pair of slits can act as a pair of sources that are in phase (coherent) if the light passes through a single slit first and the two slits are equidistant from it. This set-up was used by Young to demonstrate interference with light. Wavelength can be determined from measurements of the arrangement using Young's formula:- $\lambda/d = W/X$, where d is the distance between the two slits, X is the distance to a relatively distant viewing screen, and W is the "width" of the interference pattern formed.



Comments

(a) Well answered by many who understood the definition of g.

(b) and (c)
The quality of solutions probably reflected the amount of information written by the candidates on their formula sheets. A fairly detailed explanation accompanied by a diagram was required for full marks.

Question 9

(a)

(i) Resonance is occurring when one object absorbs vibrational energy from another. The object absorbing the energy must have a natural frequency equal to the frequency of the vibration being absorbed.

Fixed wires have natural frequencies that are related directly to the length of the wire - these are called the fundamental and overtones, for any given length. One of these natural frequencies must equal the tuning fork frequency for resonance to occur, and so, as the wire length changes it will only vibrate when one of its natural frequencies coincides with the tuning fork frequency.

(ii) The 256Hz tuning fork causes the wire to vibrate at its fundamental frequency, with a node at each end and an antinode in the middle. The 512Hz tuning fork will then cause the same wire to vibrate at its first overtone, where a node occurs at each end <u>and</u> in the middle, so the paper does not vibrate. Moving the paper to one quarter position places it on an antinode, and so it vibrates again.

(b)

(i) Magnetic field goes from right to left, from the N to the S. The conventional current through the light globe passes from back to front - "out of the page" – away from the N on the magnet.

(ii) It is alternating, because the rectangular loop between the poles always has an anticlockwise current in it (looking from "above") and it flips over as it rotates - its ends are connected to two slip rings. The current will travel towards one of them in half a revolution, and towards the other in the other half revolution.

(iii) At a maximum, as the conductor, field and direction of movement are mutually perpendicular. [$\theta = 90^o$]

(iv) The light globe would need to be replaced by a power supply and the slip rings replaced by a split-ring. The coil would then rotate continuously in the apparatus.

(c)

(i) The fuel rods, having been subjected to internal bombardment by neutrons produced by fission of the uranium in them, contain a wide variety of fission products which are highly radioactive but not fissionable themselves. "Spent" rods still contain uranium but not sufficient to maintain a neutron-flux above unity, and so cannot sustain the fission (chain) reactions.

(ii) $^{1}_{1}n + ^{99}_{43}Tc$ ♦ $^{100}_{43}Tc$

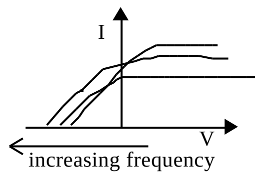
$^{100}_{43}Tc$ ♦ $^{0}_{-1}e + ^{100}_{44}Ru$, a β^{-} decay.

(iii) The fact that Tc-99 dissolves in water makes it an extremely dangerous radioactive substance - if it is not "contained" it could easily contaminate water supplies and cause horrendous problems for all living organisms. Its long half life means that if it was to be widely distributed in any area, its toxic effects would last for a very long time. It is therefore best to remove the technicium-99 so there is no chance of it being released.

(iv) The treated technicium-99, howsoever it be done, must either be not radioactive or if it is, have a short half life - if it (Tc-99) is accidentally released into the environment it will decay quickly to the relatively harmless ruthenium-100. 6 tonnes to 3 tonnes, to 1.5 tonnes, to 0·75 tonnes, to 0·375 tonnes in a minute! An extremely high, but short-lived becquerel value (activity).

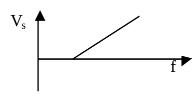
(d)

(i) It has no effect at all, because light is quantised.



(ii) Once the frequency of light has exceeded the threshold frequency for the metal (caesium in this case) , as frequency of the light increased, the stopping potential increased.

(iii) Einstein showed a linear relationship between frequency and stopping potential (once threshold had been exceeded). The equation for the linear relationship is: - $V_s = kf + c$,



where k is the gradient and c is the intercept. Einstein re-wrote the equation as, $KE_{max} = hf - W$, where KE is the energy of an ejected photo-electron, hf is the energy of the incident light and W is the energy required to liberate the photo-electron from the caesium. This confirmed Planck's earlier hypothesis that light (e.m. radiation) behaves as a particle.

Comments

(a) (i) Many candidates resorted to copying information recorded on their formula sheets without reference to the particular aspects of this question. It was expected that the concept of resonance would be explained and that this explanation be applied to this question. Some candidates are obviously unclear as to the relationships between resonance, interference and standing waves, etc.

(ii) This question was fairly well handled, presumably because it was more numerical and candidates were able more easily to model the situation. The most common error was that candidates believed the paper divided the wire into vibrating sections rather than it indicating the actual vibration of the wire.

The usual confusion between harmonies and overtones was demonstrated also.

(b) (i) Many candidates could not arrive at the correct current direction. They applied right hand and left hand rules indiscriminately without a real understanding of the situation in a generator, as distinct from a motor.

(ii) This part was generally well done except that the explanations were quite variable. To say that the current was alternating because it periodically reversed direction was not considered adequate.

(iii) This was also generally well done with most candidates gaining full or nearly full marks.

(iv) There was considerable confusion in this question. Candidates needed to be clear as to the distinction between motor and generators. Many failed to realise that a source of EMF is required in a motor. Diagrams done were generally good.

(c) This was a straightforward question and many candidates gained full marks. Marks were generally lost if candidates:

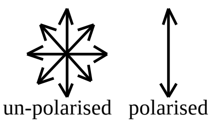
- Did not give sufficient detail to match the recommended times for each part. For example, the answer ‘fission’ in part (i) without any further comment only rated one mark.
- Did not make use of *all* the information given in part (iii).

(d) While many candidates had a reasonable understanding of the photoelectric effect, few were able to gain full marks – largely because they did not answer all parts of each question. Less than half were able to give a suitable sketch graph (as opposed to some sort of experimental diagram) for part (ii), while most simply mentioned the wave/particle duality in part (iii) without giving a good explanation of how Einstein used this.

Question 10

Part I

Part I

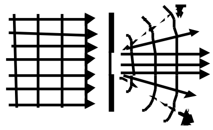


(a) Light is considered to be a pair of self sustaining fields, one electric and the other magnetic, at right angles to one another and the direction of propagation. In unpolarised light, the fields are oriented randomly. In polarised light the fields in the light all have the same direction.

(b)

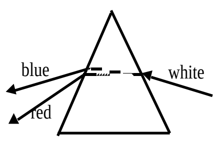
(i) Diffraction is the process by which a wave will bend around a barrier into the "shadow" behind it, or disperse from an aperture as if the aperture was the source.

ii.

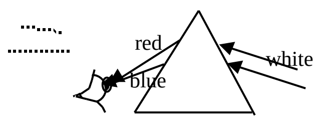


(c)

(i) Red light will pass below the blue (see diagram)



(ii) Red light will be seen above the blue (see diagram, below)



Comments

(a) This part was answered correctly by most candidates. Candidates who referred to unpolarised light as a transverse wave, comprising vibrating electric and magnetic fields (perpendicular to the direction of propagation) gave the best answers. Candidates who related polarisation to rope (string) analogies often drew meaningless diagrams.

(b) (i) Easily answered by a large majority of candidates. The major error was confusing refraction and diffraction.

(ii) This section caused problems for most candidates. Correct answers required a diagram indicating:

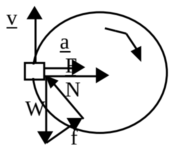
- evenly spaced wavefronts (λ the same for incident waves)
- spreading (bending) radically on both sides
- direction of rays, radically and parallel at centre
- plane waves centrally
- greater number of rays centrally, to indicate great central intensity

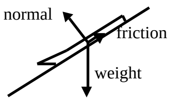
(c) (i) Answered well by most candidates.

(ii) This section proved to be too difficult and therefore was deleted from the marking scheme (sections (a) and (b) being inflated). The seven candidates who answered (c)(ii) correctly, were given bonus marks.

Part II

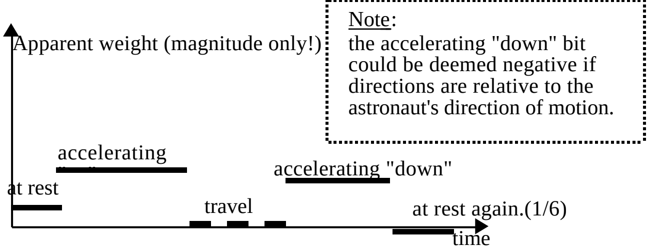
(a) The vector diagram of the three forces acting on the sled must be a closed triangle because the sled is not accelerating.





(ii) If the sled encountered a patch of ground with less friction, then the other forces would still be the same. Hence there would now be a non-zero resultant force down the hill - giving the sled some acceleration and increasing its speed.

(c)


(d)


Comments

(a) Surprisingly few candidates obtained full marks for this part. The force vector was drawn incorrectly in most incorrect answers.

(b) (i) The forces on the sled were generally well done but the vector diagram showing equilibrium was beyond the majority of candidates.

(ii) Poorly done. Very few candidates were able to show that of the functional force was reduced there was a melt force produced down the plane and therefore the sled accelerated. Candidates were awarded 1 mark for stating that if friction was reduced the sled would accelerate.

(c) 30% of candidates obtained full marks. The remainder either showed forces of unequal magnitude or drew field diagrams.

(d) Few candidates realised the apparent weight was constant in each region. There was a reasonable understanding of the relative sizes of the weight between the earth and the moon. Weightlessness for section 3 was rarely shown.

Award Summary

Outstanding Achievement (OA)	165
High Achievement (HA)	178
Satisfactory Achievement (SA)	131
Reassessed into neighbour	50
Total	524

Gender Breakdown

Males	345
Females	179

Summary of external ratings

	A	B	C	D
Criterion 2	190	250	65	2
Criterion 7	199	114	125	68
Criterion 9	122	155	137	93
Criterion 10	257	89	64	97

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