TASMANIAN SECONDARY ASSESSMENT BOARD

PH866

Physics

2002 External Examination Report

Cut off marks were as follows:

Criterion 2	Criterion 7	Criterion 9	Criterion 10
A >= 31	A >= 32	A >= 41	A >= 45
B >= 25	B >= 25	B >= 30	B >= 35
C >= 17	C >= 15	C >= 20	C >= 20

Question 1

(a) Well done including the correct units (320 Nm^{-1}).
(b) Also well done (rope A same extension as for lighter people on other ropes).
(c) Most candidates tried to calculate the area under graph C. However a significant number failed to get the correct answer (2.0×10^4J).
(d) Well done.
(e) Not so well done. Those that realised the area under the graph was the critical thing did well, but a lot failed to recognise this.

Question 2

(a) Most realised that a PE ~ 1/r graph was required. A lot struggled with the power of 10 and units of 1/r (10^{-6} m).
(b) 3 marks were given for each of drawing the graph, calculating the gradient (-3.05×10^{14}) and calculating the mass of the planet from the gradient. Very few obtained the correct value for the mass of the planet (about 4.6×10^{24}kg) mostly due to ignoring the powers of 10 when calculating the gradient. Those who plotted actual values (1.4×10^{-7}, 1.25×10^{-7} etc) were usually able to calculate the gradient. Substitution of a pair of values from the table into the equation to obtain a value for the mass of the planet was given very few marks (1).
(c) Well done (1.2 ~ 1.4 N).
(d) Most managed to plot a point but very few knew (determined by drawing more tangents) the correct shape.
(e) The correct answer was easily obtained by reading the "Potential" of the graph and multiplying by the mass (-2.4×10^{16} J).
(f) There were very few correct answers to this question. A lot of candidates had the correct shape but had it displaced up or down the page from the correct position. This was awarded 3/5. About 1/3 of scripts were left blank.

Question 3

(a) (i) Not being given the initial velocity of the comet confused many although it was not required to find the "change" in momentum. An understanding of analysis by components was required. The comet gained momentum in the direction of the motion of the probe and it was this gain in momentum (by the comet) that was required. Many tried to use momentum vector diagrams, however, not knowing the initial velocity of the comet made this difficult.

(ii) Again, 'change in momentum' confused many. Attempts to use vector triangles when the initial velocity of the comet was not known were unsuccessful. Two successful approaches using conservation of momentum were used. One involved analysing the explosion and determining that a change in velocity of 0.1 m/s resulted in the comet – then adding this to the change caused from (a)(i). The other was to apply the law to both interactions and arrive at the change in velocity in one step. Both received full marks.

(iii) A velocity vector triangle was required using the given values of 0.34 /s and 30000 /s. The angle sought was given by the inverse tan of 0.34/30000
A few candidates complained that their calculators couldn't display all the numbers – use of scientific notation was obviously lacking.

(b) (i) Many candidates stated that the force was zero since velocity was constant. Resultant force is zero only because the force of the rope balanced the weight of the rockclimber which was what was required. Hence the force exerted by the rope on the rockclimber is equal in magnitude, and opposite in direction to the weight, ie 784N upwards. Many candidates failed to give a direction to either part of this question.

(ii) Of those attempting this question, most subtracted the upward acceleration resulting in a force that was less than the weight.

Overall, Question 3 was poorly done by most with less than 25% of candidates scoring more than half marks.

Question 4

(a) (i) Generally well answered by most. A simple question requiring no more than stating the correct values.

(ii) Use of the wave equation with some justification of the values used was required. Eg for fundamental frequency of 2 Hz, wavelength is twice the length of rope ie 20m therefore v = 2Hz x 20m = 40m/s

(iii) Only a few candidates new the correct formula to use. If in fact this is on the course then perhaps the formula should appear on the formula sheet.

(b) (i)&(ii) Many candidates incorrectly drew transitions all starting from the top lines (PE=0) down perhaps confusing the other representation of the energy levels which is probably more commonly used. Also, many calculated all or most transitions instead of just those possible from the 12.5 eV electron used.

(iii) Most answered the elastic part correctly, however, few were able to correctly complete the inelastic part.

Overall, Question 4 was well answered with a majority of candidates scoring more than half marks.

Question 5

The majority of candidates attempted this question.

(a) (i) Done well although a lot of answers did not include the direction of the acceleration.

(ii) There was a variety of ways of attempting this question. As the answer was supplied candidates had to give a clear indication that they could identify the given information, assign it to the correct quantity and then place them into a relevant formula to produce the answer to gain full marks. Clear setting out assisted the marker to assign marks.

(b) (i) Attempted well. Some candidates used the mass from a)(ii) having obviously rushed their reading of the question. Units were a problem for any candidates.

(ii) Almost identical to b)(i) with the same errors occurring.

(iii) Generally done very well with many candidates comparing the acceleration of head and feet. There was some confusion on the difference between acceleration and force. Many candidates considered that the head would be violently ripped off the examiner and not appreciating the gradient in acceleration experienced through the whole body. Some attempts of humour and sympathy for the examiner, although welcome, did not gain extra marks.

(c) (i) Poorly done with most candidates being confused by the unusual units given in this question.

(ii) Poorly done with many candidates unable to identify the correct formula, instead they solved for the electric field strength using $E = (kQ)/r^2$ perhaps thinking that E = energy.

Question 6

(a) (i) Very well done.

(ii) Most well done although many candidates who were unsuccessful with this question appeared not to have the combined formula $E = (hc)/\lambda$ and thus attempted through various paths to get the answer, invariably without success.

(b) (i) Done very well by a variety of techniques.

(ii) Poorly done with the use of inappropriate symbols common. Beta particle was commonly placed on the wrong side of the equation.

(iii) Candidates were either able to do this question and gain full marks or not able to and gain no marks. Working back in time was clearly too difficult for many candidates. Guesses were common.

(c) (i) Most candidates were able to answer this question. Common errors were changing the mass of the uranium and helium entirely into energy. Also not converting amu into kg before using Einstein's equation was a common oversight. Not enough candidates chose the direct conversion of mass in amu to energy in MeV using 1 amu=931MeV.

(ii) This was most easily solved using atoms=moles x Avogadro's Number (which was not on the formula sheet). Too many candidates had obviously experimented with the number to see which combination of operations gave the required answer. The question did require more than just a numerical expression equal to the answer. To get full marks some words of justification were needed to explain each step.

(iii) The simplest solution was using $A = \lambda \times N$. Not a lot of candidates were able to solve this question, with many being unfamiliar with the concepts involved.

Question 7

(a) (i) The vast majority of candidates correctly found the magnitude, most gave the correct unit of Tesla, not Telsa, but very few were able to give the correct direction of West. An easy question.

(ii) At least **half** the candidates did not read the question properly. They found the magnitude of the resultant field and did not bother to find the direction which was all that was required. Candidates understanding of geographical bearings was generally good.

(iii) Another very easy question but most candidates did not get full marks because they either did not indicate the positive end of the conductor or they neglected to show Volts as the units. Too many wasted marks by not answering the questions asked in a(ii) and a(iii).

(iv) A very easy question generally well done by all candidates. To get full marks it was necessary to **show** the formula being used, put in the values and present the answer with appropriate units.

(b) (i) A standard question type. Common errors, as expected, included adding individual fields instead of subtracting them, presenting an answer with only one significant figure, no units and no direction indicated. Many had all of the above!
Far too many candidate waste marks by not putting directions on vector quantities and not using the correct SI units.

(ii) Most candidates correctly realised that the horizontal fields from each of the wires would be of the same magnitude but in opposite directions giving a net field, in the horizontal direction, of zero. It was evident that many candidates are confusing magnetic field strength and magnetic force.

Question 8

Questions were sometimes not read carefully. Although candidates gave correct physics, they may not have answered the question that was asked.

(a)&(b) Many candidates lost marks because they gave answers without reasons or explanations.

(c) Some candidates thought that nuclear reactions involved electrons of the inner shells, rather than the nucleus. Most people mentioned the greater energies associated with nuclear reactions but failed to relate this explicitly to the frequencies and groupings (eg gamma vs visible), which is what was asked.

(d) A number of candidates talked about the photoelectric effect without relating it to the context of the question. A number were careless with their language, eg using the terms momentum and energy interchangeably. Many claimed that the increased frequency produced *more* electrons, rather than merely increasing the kinetic energy of those already released. An important part of this question was the mention of the work function and/or threshold frequency, and relating this to the wavelengths given in the question.

(e) Generally done well. Again, some people were using the terms momentum and energy interchangeably, while others used the words energy and power interchangeable. A number of people claimed that increasing the wavelength also increased the frequency. Some people failed to give careful step by step reasoning in their answers.

Question 9

(a) (i) Majority of candidates received the full mark.

(ii) Full marks were given provided candidates indicated continuous or chain reaction – other similar comments were accepted. Some candidates talked of balanced reaction and conservation of energy – this was not accepted.

(iii) Most candidates scored at least 2 marks by being able to explain in reasonable terms the significance of the short half life. Although many candidates stated incorrectly that the "short half life removed the isotope from the body quickly" and failed to discuss the impact of reduced activity they were not penalised. To gain full marks candidates were expected to discuss fully the need for the □radiation to leave the body, minimum ionising effect of □, as well as the impact of the □-radiation that would be absorbed in the body. Quite a number of candidates, incorrectly, tackled the question from the point of view of the radiation being absorbed from outside the body.

(iv) Most candidates scored at least $1^{1}/_{2}$ marks. Full marks, 3, require candidates to provide a reasonably constructed answer (dot points accepted) that listed three significant problems. Eg Need to and difficulty in isolating the waste, length of secure stable storage required or significance of leakage to the environment.

(b) (i) Quite well answered with most candidates receiving the full mark. Some candidates attempted to include the impact of the dust particle's field – this was ignored.

(ii) This was in general not well answered. Candidates were expected to recognise that $E \propto 1/d$ and thus the field strength is stronger at the negative charge. Some candidates compared the charge density at the wire with that on the surface of the chimney while others discussed the variation in the density of field lines. These candidates were given near the full 3 marks depending on their discussion.

(iii) In general this question was poorly answered. Candidates often failed to clearly draw the forces to scale on the diagram provided. Very few candidate candidates related the magnitude of the forces through $F = Eq$ and further more recognise them as unbalanced and thus describe the dust particle's motion as accelerating towards central positive wire.

(iv) Most scored well on this question.

(c) Generally well answered. Many candidates could not give a clear definition of a 'longitudinal wave' (part (i)) and standing wave patterns were often drawn in an ambiguous way in parts (ii) and (iii) In part (iv) it was not enough to simply state that points B were nodes and A were antinodes – some explanation of what was happening was required. Many simply quoted a formula (often incorrectly) in answer to part (v). Mention of the formula $v = \lambda f$ without further discussion only gained one mark, and mention of the various formulae for harmonics only gained full marks if they were explained.

(d) Of the four parts to question 9, this question was least frequently attempted. Part (i) was generally not well done, with few candidates managing to give an acceptable current carrying coil, and many getting the forces, charges and load currents in the wrong direction. Part (ii) was generally well done when attempted, but there were relatively few attempts.

Question 10

Both parts of this question were quite well answered.

Either

(a) A lot of candidates did not notice the question at all.

(b) Nearly all candidates knew the answers to this part.

(c,&d) This was the most difficult part of the question and very few candidates got full marks. Only those candidates with a good understanding of how interference occurs could answer this part.

(e) Most answers were correct.

(f) (i) The question was not read carefully by many candidates, many candidates answered "the refracted ray", which was not involved in this part of the question.

(ii) Surprisingly well answered and most of the answers were well written which assisted with candidates criterion two mark for this question.

Or

(g) (i) All sorts of problems here, arrows not to scale, air resistance much too big – it could have been ignored, too many arrows drawn – only forces acting **on** the climber required. Full stretch forces not properly understood.

(ii) Generally well answered.

(iii) Very few candidates drew the correct vector triangle. Tension forces often going the wrong way, sometimes weight going the wrong way!

(iv) Difficult to answer if part iii) was not correct. Few candidates realised that the constant weight vector was the key factor and that decreasing the angle must involve an elongation of the tension vectors.

(h) (i) A disaster as it is every year. Probably 50% of candidates had the forces unequal. Many had the forces as repulsive rather than attractive and some had both! Needs to be concentrated on by teachers.

(ii) Both parts answered reasonably well. The question wanted to know what **happened** to the momentum and energy and simply saying it was zero as the comet had stopped was not good enough. In both **cases the quantity was conserved, either by something else or in another form.**

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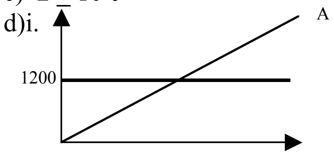
Physics C 2002 November Solutions

1. a) Cord A has the greatest stiffness. 320Nm^{-1}.

b) Cord A – having a large body mass, Jo needs a larger force to be brought to rest at the end of the stretched cord.

c) 2 _ 10^4J

d)i.

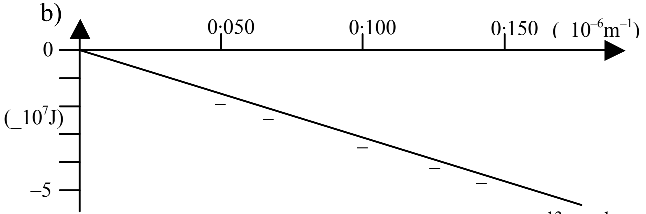


ii. When Jo has fallen 15m, the area under both graphs is the same, meaning that the energy gained by Jo in falling 15m (1200N force for 15m = 1·8_10^4J) is equal to the energy gained in stretching cord A for 15m (_ of 15 _ 2400)

2. a)

PE	–4·35	–3·86	–3·09	–2·47	–2·06	–1·54
Dist	7·0	8·0	10·0	12·5	15·0	20·0
1/r	0·143	0·125	0·100	0·080	0·067	0·050

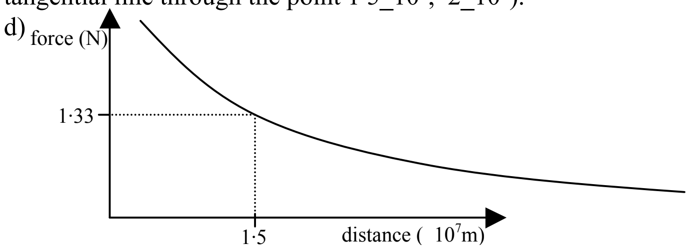
b)



gradient of this graph is approximately –32_10^{13}Jm^{-1}. The gradient should equal –GM, and so M = 32_10^{13}/6·67_10^{-11}= 4·80_10^{24}kg.

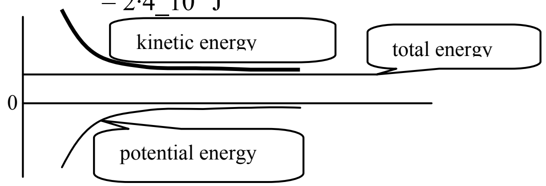
c) Force acting is about 1·33N (the gradient of a tangential line through the point 1·5_10^7,–2_10^7).

d)



e) i. Surface of planet is 6·4_10^6m from its centre, corresponding to PE of –4·8_10^7Jkg^{-1}. Thus PE of approaching comet is –4·8_10^7_5·0_10^8
= 2·4_10^{16}J

ii.

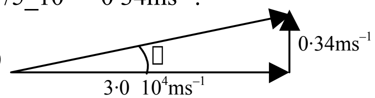


3. Note: This question is done by ignoring the forward motion of the comet – its velocity change is deemed to be only in the initial direction of the probe.

a) i. □p_{probe} = 4000 _ 3_10^4 = 1·2_10^8kgms^{-1} ("out").
So, □p_{comet} = 1·2_10^8kgms^{-1}, and □v = 0·24ms^{-1} ("in").

ii. □$p_{material}$ = 5_10^4 _ 1·0_10^3 = 5_10^7kgms^{-1}("out").
So, □p_{comet} = 5_10^7kgms^{-1}("in"), and total change in momentum (impact & explosion) = 1·7_10^8kgms^{-1}("in").
□v_{total} = 1·7_10^7/5_10^8 = 0·34ms^{-1}.

iii.
tan□ = 0·34/30000
□ □= 0·00065º



Note: If this question was done in the "standard way", the triangle is effectively redundant, having two "equal" sides and a right angle. This arises because the "new" speed of the comet (and probe) after the collision is still 3_10^4ms^{-1} on the display screen of most standard calculators.

b) i. when abseiling without acceleration, forces are balanced so |tension| = |weight| = 80_9·8 = 784N up.

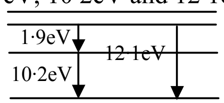
ii. when accelerating up (reducing downward speed)
|tension| = |weight| + |unbalanced force|
= 80_9·8 + 80_2 = 944N up.

4. a) i. 4Hz, 6Hz and 8Hz

ii. For the 2Hz vibration, □ = 20m (internodal distance =10m) and f = 2Hz.
v =□f = 20_2 = 40ms^{-1}.

iii. Since v = (T/□), T = v^2□ = 40^2_0·02= 32N

b) i. 1·9eV, 10·2eV and 12·1eV.



ii. elastic: 12·5eV
inelastic: 0·4eV, 2·3eV and 10·6eV

5. a) i. ac = v^2/r = (8_$10^5)^2$/(3_10^{15}) = 2·13_10^{-4}ms^{-2}.

ii. g = GM/d^2 □ M = gd^2/G
= 2·13_10^{-4} _ (3_$10^{15})^2$/6·67_10^{-11}.
= 2·89_10^{37}kg (2·9_10^{37}kg)

b) i. g = GM/d^2 = 6·67_10^{-11} _ 6_10^{24}/3^2
= 4·45_10^{13}Nkg^{-1}.

ii. g = GM/d^2 = 1·6_10^{13}Nkg^{-1}.

iii. since the examiners head is accelerating at a greater rate than his feet, the two ends of his body cannot remain a constant distance apart, (unless he is spinning around an axis near his knees). In either case his body will be stretched as the head is accelerating away from his feet.

c) i. E = 16kVcm^{-1} is the same as 32kV for 2cm. The *potential difference* is therefore 32kV.

ii. work done = □Energy = qV = 2_10^{-6} _ 32_10^3
□ total energy in spark = 6·4_10^{-2}J

6. a) i. 18MeV = 18_10^6 _ 1·6_10^{-19}J = 2·88_10^{-12}J.

ii. $□_{min}$ = c/f = hc/E = 6·63_10^{-34} _ 3_10^8/2·88_10^{-12}
= 6·91_10^{-14}m

b) i. After 4 half lives activity = 1(0·5)^4 = 0·0625GBq.

ii. $_{42}Mo^{99}$ □ □ $_{43}Tc^{99}$ + $_{-1}e^0$.

iii. Half a half-life before, A_o = 1(0·5)$^{-–}$ = 1·42GB

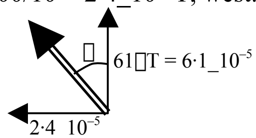
c) i. mass loss per atom
= 239·0522 – 235·0439 – 4·00260
= 0·0057amu
energy released = 0·0057_931MeV = 5·31MeV.

ii. no of atoms = 100g/mass of 1 atom
= 0·1/(1·66_10^{-27} _ 239·0522)
= 2·52_10^{23} (atoms)

iii. no. of decays per second = activity (A) =□N
□ = 0·693/T_ = 0·693/7·7_10^{11} = 9·00_$10^{-13}s^{-1}$.
A = 9_10^{-13} _ 2·52_10^{23} = 2·27_10^{11}Bq (decays)

7. a) i. B = KI/d = 2_10^{-7} _ 1200/10 = 2·4_10^{-5}T, west.

ii. tan□ = 2·4/6·1
□ □= 21·5º
field points N21·5ºW.

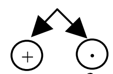


iii. emf = vℓBsin□
= 5 _ 0·5 _ 2·4_10^{-5} _ sin90º
= 6_10^{-5}V or 60□V

iv. E = V/d = 6_10^{-5}/0·5 = 1·2_10^{-4}Vm^{-1}.

b) i. At P the two fields oppose each other (RHGripRu
B = KI/d gives 2·4_10^{-5}T up and 2·37_10^{-5} down, giving a total field of 2·4_10^{-7} up.

ii. Total field strength at any point above the midpoint between the cable will be due to both cables. Each fielc will have equal but opposite horizontal components thai cancel each other.



8. a) A higher average frequency for hot objects (more energy being emitted)

b) Gamma radiation (□) is able to ionise more because it has the most energy.

c) Nuclear energy is greater than electronic transition energies (produced by heating matter) and so high frequency radiation is emitted, such as gamma rays.

d) □ must be below a threshold value for PE effect to eje electrons (400nm in this instance). 250nm UV is more energetic than 400nm, so ejected electrons are more energetic (KE = hf-W) and hence more likely to escape and produce erasure.

e) Category B, since it has a shorter wavelength and he a higher frequency and so more energy.

9 a) i. "Fissile" means (in a geological sense) able to be broken into fragments. In the above reaction the U-235 is being broken into smaller fragments. The process has been called *fission*.

ii. More neutrons on the right can then interact with other nearby U-235 and cause a *chain reaction*.

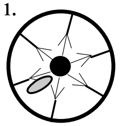
iii. 1. A short half-life means that a small amount of isotope can be used, sufficient to give enough radiation to be detected. Also it means that the isotope does not remain at full strength for a long time, perhaps disappearing from the body completely after several half-lives.

2. α and β emissions are not as penetrating as γ emissions and so may not reach the external detector. Furthermore they would be causing unnecessary damage to the patient without any benefit. The γ emissions, although potentially more damaging, are only so if absorbed, an occasional event considering their high penetration.

iv. Long half-life: exist for long periods with little decrease in activity. Short half-life: although only transient, have high activity initially, even in small amounts. γ and β radiation is quite penetrating, meaning that they potentially reach considerable distances from the source where they may be damaging to organisms. α-radiation has little penetrance and so is not very dangerous over distances greater than a 10 cm.

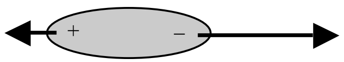
When disposing of these unwanted isotopes, safety for humans, other animals (food) and plants (food) is of concern. Contamination of large areas of land and oceans (leaching by ground water) is possible, potentially causing structural, metabolic and genetic damage to living organisms over a wide distribution.

b) i.



ii. The negative end of the dust particle is in a stronger electric field than the positive end. The two ends are equally charged (opposite), so F = qE is greater for the negative end.

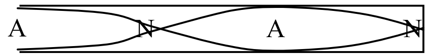
iii. Forces are unbalanced, so particle accelerates, moving towards the central wire.



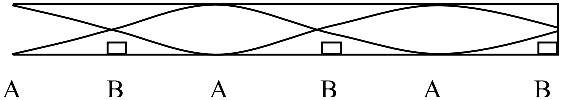
iv. Being positively charged, the dust particle will be repelled from the central wire and attracted towards the (negative) chimney. The dust particle accelerates away from the central wire and will move in that direction if stationary after its collision with the central wire.

c) i. It means that the air particles that transmit the sound vibrate back and forth along the line of propagation of the sound.

ii. for example:



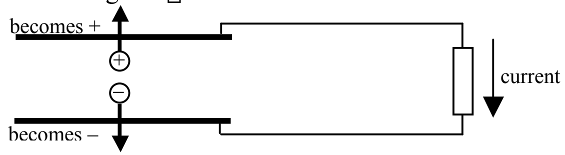
iii.



iv. The grains of powder are being struck by moving air particles, causing them to move – eventually they will accumulate in a spot where they are no longer affected by vibrating air particles and no longer move – at the nodes of the standing wave in the air column.

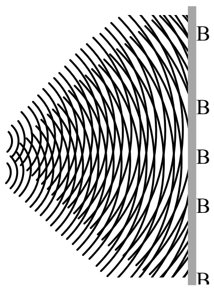
v. The distances between piles of powder could be measured, yielding a value for wavelength (adjacent piles are λ/2 apart). Then, knowing frequency, speed could be determined using v = λf.

d) i.



ii. The stationary copper plate does not move in the magnetic field and so has no currents induced to flow in it. When moving, the copper plate has induced currents in it, and forces acting on these induced currents which oppose the change that causes them (Lenz's Law). The change is caused by the motion of the plate, and the forces opposing this motion thereby tend to bring it to rest.

10. a)



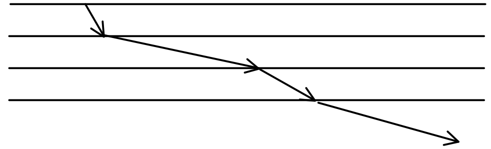
b) i. There are dark fringes between the bright fringes because the two sources are destructively interfering at these points. At the bright fringes constructive interference occurs.

ii. When each narrow beam from the light source reaches slit A (or slit B) it diffracts as it passes through the slit, meaning that the light spreads out into the "shadow" area beyond the slits.

c) The fringe pattern will shift down the screen until it coincides with initial pattern. This is because there is a gradual change in phase between the two slit sources as the path length to A increases, causing an ever increasing delay in the time corresponding wavefronts leave A compared to those leaving B.

d) The pattern on the screen can be made quite large (visible and measurable) compared to the distance fron the primary source to either slit. Small changes in one source-slit distance cause the interference pattern to mo relative to itself, the proportional amount of movement being proportional to the fraction of a wavelength chan in the source-slit distance.

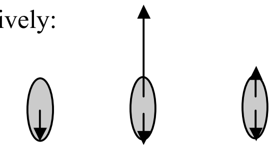
e)



f) i. Direct. It has a shorter distance to travel at the same speed (same medium).

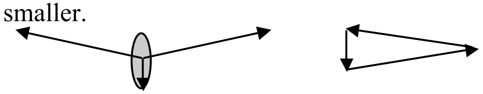
ii. The refracted wave will enter the rock travelling alm parallel to the soil/rock boundary. When it reaches R a again enters the soil on its way to the detector it has travelled a long distance in perhaps a shorter time than direct ray, which is travelling *almost* as far but in a mu slower medium.

g) i. respectively:



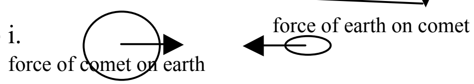
ii. A stretchy rope will stop the falling rock-climber ove longer distance, with a smaller force. Same energy to los ΔE = W.D. = F_s. <u>Alternative:</u> longer stopping distance a same initial, final speed means more time [t = 2s/(u+v)] to lose same momentum. F (=Δp/t) is therefore smaller.

iii.



iv. If θ is small then the tension in the rope can get very large.

h) i.



ii. 1. The momentum of the comet is partly transferred t the earth and partly retained by the comet or its fragment The comet/earth system simply redistributes its momentu in such a way that each has a proportion of the original to amount that is exactly shared in the ratio of their respecti masses.

2. The kinetic energy of the comet is largely converted i "other" forms of energy, much if which is atomic and molecular kinetic energy or "heat".