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

2001 External Examination Report

General Comments

For the most part, this was a rather straightforward paper with questions requiring routine answers, and the raw marks were correspondingly higher than is normal. In future years it may be best to include a greater proportion of more searching questions in the paper.

The final breakdown of marks was as follows:

Criterion 7 (Section A)	A ≥ 34 B ≥ 28 C ≥ 16
Criterion 9 (Section C)	A ≥ 45 B ≥ 35 C ≥ 23
Criterion 10 (Section B)	A ≥ 60 B ≥ 50 C ≥ 32

Criterion 2
Average Total = Section A + Section B (sum of best 4)/4 + Section C (sum of best 3)/3

Average Total	A ≥ 12 B ≥ 10 C ≥ 5

Section A – Criterion 7

Question 1

(a) Most students correctly read the value of 27.0m from the graph. A few students however, calculated an area under the graph. It was easier to assess this question when students had shown the reading on the graph given. The calculation of speed was almost always correct given the correct value obtained in (i). The question specifically asked students to use the graph, but many failed to show how they had done so.

b) (i) Mark was given for simple yes/no answer. Many showed they could not read the correct value from the graph of the stopping distance for car A, even though the incorrect value they provided was not required.

(ii) Was often poorly done, because students failed to *show* how they obtained an answer of 10m/s. Frequently, numbers bearing no resemblance to those on the graph were concocted in order to obtain a value of 10m/s. Examiners looked for some indication on the graph of where the gradient of a tangent or similar technique was used to validate the answer. Students who obtained an answer close to 10m/s by using a tangent were given full credit.

(iii) Students often made general statements about road safety without reference to the values obtained in (i) or (ii) as they were required to do. Reference to stopping distances and impact speeds were critical in an analysis, as was the large difference in stopping distance and impact speed given a relatively small difference in starting speeds.

Question 2

Many students often missed the simplest relationship- ie $s \sim u^2$ and gradient of 1/2a
In failing to do this, the task was made much more difficult. A significant number of students successfully completed the question by drawing a graph of $s^{-} \sim u$. Students were penalised under C2 for failing to put correct units in their table or on the graph axes.

(b) Some students failed to show clear understanding of dependent and independent variables and their correct placement on the graph. A large number of students failed to draw a line at all, or failed to draw a best-fit straight line through the first 6 points. Students were not heavily penalised because the examiners accepted some ambiguity in the wording of the question.

(c) Students often failed to show that they understood the need to use the gradient of the graph, and pulled data straight from the table, substituted in the given equation and calculated the acceleration. Although such a procedure often gave the correct answer, students were heavily penalised for failing to demonstrate that they used the graph as the question required them to do.
It may be instructive for teachers to note that students are required to understand that a gradient (as in this case) is given by

$\Delta s/\Delta u^2$ and not simply s/u^2. This misconception encouraged students to attempt to reach a value from individual data points rather than from a trend given by the graph.

(d) This was well done by those students who had successfully completed the earlier parts of the question.

Question 3

This question specifically required students to use data and conclusions from Questions 1 and 2 *and* relate them to the graph on page 9. Examiners were looking for:

- impact of small change in initial speed on stopping distance (from qn1);
- obstacles struck at speeds of 10m/s or more can cause death (from qn2);
- stopping distance proportional to u^2, and hence a small increase in u results in a large increase in stopping distance.(from qn2);
- the deceleration at speeds greater than 25m/s is less than for lower speeds. Clearly demonstrated in graph at qn 2(d);
- Combination of factors above results in the exponential relationship of the graph on p9. The low impact speed required for a fatal collision contributes to the rapid rise in casualty rate at higher speeds of 65km/h or above.

Students who produced 4 out of 5 points (stated in an equivalent or similar way to above) would have scored full marks. The more common answer was one or two of the above, which scored 2 - 4 points out of 7. A large number of students introduced irrelevant information and opinion without focusing on the data and information they were asked to analyse, and from which they were required to draw their conclusions.

Question 4(a)

(i) Many did not label the diagram to show clearly that the vectors were **momentums** (**not** velocities or cars).
(ii) Well done by many. Students needed to show clearly they were working with **momentums** from the diagram. The vector nature of momentum was frequently ignored.

Question 4(b)

(i) (ii) Generally not well answered. Students did not understand the nature of the various forces involved, particularly what was the resultant force. Students would do better to concentrate on understanding the forces provided by the chair **on** the person, rather than using an equation to try and get the right answer.
(iii) Well answered. Just the usual careless mistakes with units (km to m). A few people did not add the altitude to the earth radius.

Question 5

Generally well done. Common mistakes were:
(1) not realising that q (proton) = 1.6×10^{-19} C in (a) (ii).
(2) not taking the energy **difference** $(6{\cdot}77 - 3{\cdot}59)\times10^{-19}$ in calculating wavelength in (b). Many gave unclear answers such as "into the page" for c (ii) – few seemed to be able to visualise the situation.

Question 6

Generally well done with a very high attempt rate.

(a) (iii) The definition of resonance gained no marks, students were asked to explain. Being a criteria 10 question some formula proof was required. Answers were too wordy.

(b) (ii) Again students wrote too many words for Criteria 10. Explanations of path difference and interference were good. Many students said path difference was $\frac{1}{2}\lambda$ not $2\frac{1}{2}\lambda$. Numbers were required to be used to gain full marks. Many students used nodes and antinodes to describe parts of waves/pulses eg."node interfering with antinode" instead of crest/trough interaction.
This question would have been better stated as "explain with appropriate calculations".
(b) (iii) Many answers were too wordy without calculations. Some students used youngs double slit equations and diagrams. Students needed to state that path difference was 5λ. Many students said the sound would be louder but gave no reason. Some inferred that as $\lambda \downarrow$ amplitude $\uparrow$ louder.

Question 7

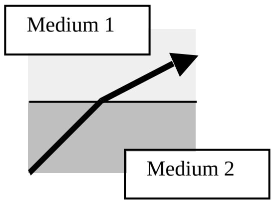
(a) (i) Some confusion between gravitational force and gravitational acceleration.
(ii) Well answered. Some carelessness with units (cm to m).
(b) All parts well answered. In part (iii) students were required to state that the initial perpendicular velocity was zero. A vector diagram was necessary as part of the answer to part (iv).

Question 8

(b) Well done by many, but little attempt made by a significant number (time a problem?).

Question 9

(a) Light travels faster in Medium 1. Evidence for this is that the light is bending away from the normal as it passes into Medium 1.

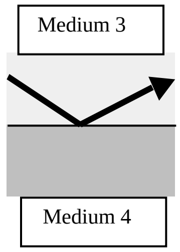


The shading in the diagram did not imply a relationship to optical density of the medium as some students thought.
The only evidence was the manner of bending of the light ray.

Many students spent a lot of time discussing why light bends as it changes medium however unless this was related to the question given, marks were not awarded.

Overall, quite well answered by most students.

(b) Light travels faster in Medium 4. Evidence for this is that (as told in the question) Total Internal Reflection is being depicted and this can only occur when light travels from a more optically dense medium into a less optically dense medium - through which light travels faster. Some reference to Snell's Law and critical angle was required for full marks.

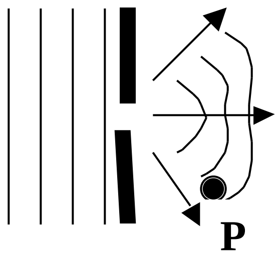


Again some students related the shading in the diagram to properties of optical density. Common errors in thinking included:

- faster through Medium 3 because it doesn't go through Medium 4;
- medium 4 is too dense to allow light to travel through;
- light travels at a constant speed – same speed in both Medium 3 and Medium 4.

Overall, quite well answered by most students.

(c) The narrow slit acts as a series of point sources (Huygen's Principle) and each points transmit light in all directions. The resultant wave front is the sum of all wave fronts produced by all the points and at the edges of the slit the points cause the emerging wave to be curved as shown. This process is called **diffraction**.



Most students produced a reasonable diagram but gave very poor reasoning – if any. Most ignored the relevance of wavelength that should not have changed in the process. Many confused refraction with diffraction.

Overall, reasonably well answered.

(d) A discussion Total Internal Reflection (TIR) was required – given the hint stated. Radiowaves must travel faster through the ionosphere than through the atmosphere shown to enable TIR to occur. Also, the incident angle shown, φ, must be greater than the critical angle for the atmosphere / ionosphere interface.

Some students were confused about the requirements for TIR.
A common error was to refer to TRI occurring when φ was smaller than the critical angle.
Others saw the ionosphere as some impervious boundary (mirror) through which radio waves could not pass.

Generally well answered.

Question 10

(a) (i) Students were not careful in their reasoning, and often neglected to relate to specific laws and concepts. Most students used Newton's 3rd law, but many were unable to use it correctly and referred to irrelevant issues such as forces on the Earth or surrounding air.
A few students used conservation of momentum, with more success.

(a) (ii) Many answers were irrelevant. Many students only mentioned the variation in collision time Δt, without capitalising on it in the context of $F = \frac{\Delta p}{\Delta t}$

(b) (ii) Many students had field lines crossing, or had drawings in which field lines were not continuous.

(b) (iii) Many explained **what** would happen but not **why** (in terms of Lenz's law).
Many talked about only magnitude or only direction. Both were required.

(c) (i) These were generally well answered.
Full marks required some mention both of the amplitudes at the node and antinode and also the cause of these differences.

(c) (ii)

- Particle at node has zero displacement and particle at antinode has maximum displacement.
- At node there is destructive interference between travelling waves and at anti-node there is constructive interference.
- Reference should be made to diagram in part (i).

(c) (iii)

- Walking people add energy to the bridge / walking people exert a force on the bridge.
- If the frequency of walking is the same as the resonant frequency of the bridge, the input of energy (applied force) reinforces the natural vibrations of the bridge, which become amplified. Consequently, the amplitude of vibration may build up to dangerous levels.
- Full marks required both a mention of the concept of resonance and some explanation of how a repetitive small input can give rise to a large amplitude of vibration. Many students simply mentioned that there was a resonance without giving any further explanation.

(d) (i) These were generally well answered.

- Electrons are produced at a (heated) cathode.
- Electrons are accelerated through a high potential difference to a tungsten target (an anode).
- The rapid deceleration of the electrons at the target causes the energy of some (about 2%) of the incoming electrons to be converted to the energy of an X-ray photon which is emitted from the target.
- Should have a diagram to illustrate: either diagram of the Coolidge tube or diagram of electron being deflected around nucleus.
- While most students answered this very well, some simply wrote down all they knew (?) about the *properties* of X-rays without giving adequate discussion of their production.

(d) (ii) For full marks, students had to indicate that the sides of the triangle corresponded to a momentum rather than just a wavelength.

(d) (iii) Not well answered, with most students forgetting that wavelength was inversely proportional to energy / momentum.

Question 11

a) & b) Most students attempted this question and the average mark was about 6/15. Diagrams should have labelled arrows to slow the direction of the force. Unlabelled diagrams and diagrams showing accelerations instead of forces received no marks. In parts (ii) and (iii) the majority of students were of the opinion that there was an outward force acting on the person, and in part (b) many thought there was a forward force pushing the person out of the seat. Many students thought the centripetal force acted outwards and no balanced weight force in (ii) and created the apparent weight in (iii). A majority of students were unable to explain how the apparent weight was related to the forces acting on the person.

b) (ii) Was well explained by most students.
Students need much more practise in this area in order to understand the concepts of forces, especially when referred to circular motion, where many thought Fc was a "real" force and not to be provided by some physical force.

c) & d) About 25% of students attempted this question, which was well answered with an average mark of about 10/15.

c) (ii) The angle of dip was not well understood, many confusing it with the angle of declination.

d) (i) A few students wrote up and down as answers for BC and DA instead of out of the plane and into the plane.

d) (iv) A number of students had the wrong direction of rotation despite having the correct answer to the earlier parts.

All correspondence should be addressed to:
Tasmanian Secondary Assessment Board
PO Box 147, Sandy Bay 7006
Ph: (03) 6233 6364 Fax: (03) 6224 0175

Email: reception@tassab.tased.edu.au
Internet: http://www.tassab.tased.edu.au

Section A

1. a) i. Reading the graph, car B has travelled 27m in the first 1·5 seconds.

ii. The gradient of the straight line section for car B is rise/run. For the first 1·5 sec, the car travels 27m in 1·5 sec = $18ms^{-1}$.

b) i. Car A does not hit the obstacle because it stops at 42m, 1m short of the obstacle.

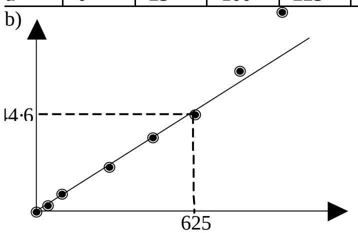
ii. Car B collides with the obstacle at 2·625 seconds. A tangent constructed at this point on the graph will estimate the car's speed by its gradient. The gradient is approx $10ms^{-1}$.

iii. Car B was travelling at a greater speed than Car A, but only by about 12·5%, which does not sound significant. However, when it is necessary to stop quickly the slight excess in speed has a significant impact on the outcome – the speeding car has lost very little speed (less than half) before colliding with the obstacle. The safer, slower speed allows the car to stop in time.

2.a) Table with modified data is:-

s	0	1·8	7·1	16·1	28·6	44·6	66	94
u	0	5	10	15	20	25	28	30
u^2	0	25	100	225	400	625	784	900

b)



The first 6 points form a fairly linear plot with gradient approximately 0·0714. (The value obtained will vary from 0·071 to 0·072)

c) gradient of s~u^2 = 1/2a

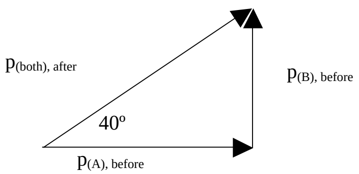
Hence a = $7ms^{-2}$, approx.

d) The deceleration is less for cars travelling faster than $25ms^{-1}$, because the gradient of the chord connecting the origin and the relevant point on the graph is greater. Since a = 1/(2×gradient), a decreases as g increases.

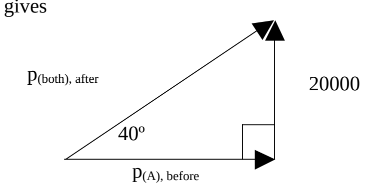
3. Question 1 tells us that cars travelling faster have greater stopping distances than slower vehicles when they have the same deceleration. Question 2 tells us that as initial speed increases there is little change in deceleration provided that speed is not excessive. Once speed becomes excessive not only is there a reduction in deceleration, but this, coupled with the increased stopping distance, means that cars are still travelling quite fast when they reach an unexpected obstacle that appears in their path. The higher speed of impact is likely to cause much more serious injury (casualty).

Section B

4.a) i.



ii. $p_{(B), before}$ = 1000 × 20 = 20000kgms^{-1}, so putting numbers in the triangle above gives



Using simple trigonometry gives:- tan40º = 20000/$p_{(A)}$.

Hence $p_{(A)}$ = 20000/tan40º = 23800kgms^{-1}, and so the speed of car A is 23800/1000 = <u>23·8</u>ms^{-1}.

b) i. At take-off, from anywhere, resultant force required is given by F = ma = 80 × 25 = <u>2000</u>N (upwards).

ii. When leaving earth, upward force exerted by the padded chair needs to accelerate the astranaut <u>and</u> overcome the gravitational attraction of earth(9·8N per kg). The force exerted by the chair is thus:-

2000 + 80×9·8 = <u>2780</u>N (upwards).

iii. According to Kepler's law, $GMT^2 = 4\pi^2r^3$. Substituting and manipulating gives:-

$T = \sqrt{\{4\pi^2[(6387+400)\times10^3]^3 \div[(6·67\times10^{-11})\times(6\times10^{24})]}$

= <u>5550</u>s = <u>92·6</u>min.

5. a) i. t = s/v = $1·5\times10^{11} \div 6\times10^7$ = <u>2500s</u>

ii. r = mv/qB = $1·67\times10^{-27} \times 6\times10^7 \div(1·6\times10^{-19} \times 8\times10^{-5})$

= <u>$1·25\times10^7$m</u>

b) $\lambda = c/f = ch/E = 3\times10^8 \times 6·63\times10^{-34} \div [(6·77 – 3·59)\times10^{-19}]$

= <u>$6·25\times10^{-7}$m</u>

c) i. B = KI/d = $2\times10^{-7} \times 5\times10^6 \div 100\times10^3$ = <u>1×10^{-5}T</u>

ii. From east to west (using the RH grip rule or equivalent)

6. a) i. The internodal distance is 2·4m and corresponds to half a wavelength. Hence λ = 4·8m. f = v/λ = 320÷4·8 = <u>66·7Hz</u>.

ii. The next harmonic will be the first overtone of this pipe and will have two internodal distances in 2·4m. Hence λ = 2·4m, and f = v/λ = <u>133Hz</u>.

iii.Sound waves travelling across the shower would resonate if they had a wavelength of 2·0m, (twice the width of the shower). f = 320/2 = 160Hz.

b) i. An organ emitting a 160Hz note is producing a sound with wavelength 2 metres, because λ = v/f = 320/160 = 2m.

ii. The wave travelling along OAL travels 5m further than the wave travelling along OL, that is 2·5λ If there is no phase change on reflection at A then the waves will destructively interfere at L and produce a low amplitude oscillation. <u>HOWEVER there IS a phase change at A and so constructive interference will occur and the sound heard will be LOUD</u>.

iii. A 320Hz note has a wavelength of 1m. The path difference is 5λ, and accounting for the phase change on reflection, the two waves will destructively interfere and the sound heard will be softer. (If no phase change on reflection the sound will be louder!)

7. a) i. W = mg = $1·5\times10^{-16} \times 9·8$ = <u>$1·47\times10^{-15}$N</u>

ii. q = F/E = Fd/V = $1·47\times10^{-15} \times 1·00\times10^{-2} \div 46·0$ = <u>$3·20\times10^{-19}$C</u>

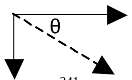
b) i. $v = \sqrt{(2E_K/m)} = \sqrt{(2qV/m)} = \sqrt{(2 \times 1·6\times10^{-19} \times 1140 \div 9·11\times10^{-31})}$

= $2·00\times10^7ms^{-1}$.

ii. t = s/v = $5·0\times10^{-2} \div 2·00\times10^7$ = <u>$2·50\times10^{-9}$s</u>

iii. v = u + at = 0 + $5·0\times10^{15}\times2·50\times10^{-9}$ = <u>$1·25\times10^7ms^{-1}$</u>.

iv.



tanθ = sideways v / forward v

= $1·25\times10^7 \div 2\times10^7$ = 0·625

<u>θ = 32º</u> Electrons are deflected by 32º.

8.a) i. $_{95}Am^{241}$ ¾→ $_{93}Np^{237}$ + $_2\alpha^4$ + $_0\gamma^0$.

ii. N = A/λ = AT_/0·693 = $35\times10^3 \times 1·36\times10^{10} \div 0·693$ = <u>$6·87\times10^{14}$atoms</u>

iii. mass converted to energy = 241·05862 – 237·04817 – 4·00260

= 0·00785amu = <u>7·31MeV</u>, per atom.

b) i. KE = hf –W = hc/λ – W

= $6·63\times10^{-34} \times 3\times10^8 \div 500\times10^{-9} – 3·09\times10^{-19} = 8·88\times10^{-20}$J

=$8·9\times10^{-20}$J

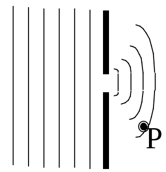
ii. EMF must stop the most energetic electrons which have $8·9\times10^{-20}$J of energy. This is 0·555eV, so a stopping potential of <u>0·555V</u> is required.

Section C

9. a) <u>Faster in medium 1</u>. The light is bending away from the normal, indicating that the wavelength is increasing. The wave therefore travels further in unit time.

b) <u>In medium 4 it has the greatest speed</u>. As the speed increases the wave bends away from the normal. In this case it bends away to such an extent that it cannot enter the new medium and so is reflected from the boundary, totally.

c) The aperture acts as a series of point sources that transmit light in all directions, including towards P. Thus some light reaches P as shown by the wavefronts in the diagram. The process is called diffraction.



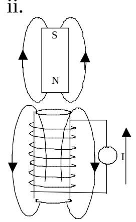
d) The ionosphere may be a faster medium for the transmission of radio waves. Light may travel slower in the atmosphere due to the relative density of air and little ionisation. In the ionosphere the "atmosphere" may be less dense and the presence of ions may facilitate the propagation of radio waves.

10. a) i. A rocket engine and its fuel has zero momentum relative to itself. High-speed exhaust gases have momentum in their direction of travel. If the momentum of the system is to remain unchanged, then the rocket must have an equal and opposite momentum to the expelled gases. Thus the rocket has changed velocity (accelerated) in the opposite direction to the expelled gases.

ii. The "crumple zone" at the front of newer cars effectively prolongs the duration of the collision and increases the distance travelled by an occupant during the collision. Both changes reduce the size of the force decelerating an occupant. In the first change, the momentum change of the occupant, mv equals Ft, the impulse of the force. If time is longer (larger), then F is smaller. Time is increased because the windscreen of the car moves forward with the crumpling car so the occupant does not stop abruptly with first contact, but decelerates more slowly (with the windscreen as it moves forward). The second change, distance, decreases the force because change in energy equals Fd, and an increased stopping distance decreases the force. Stopping distance increases for the occupant because the windscreen finally stops closer the front of the car with newer cars fitted with crumple zones.

b) i. Lenz's Law says that the induced current always opposes the change that caused it. When a conductor is in a magnetic field it has no current in it unless a change occurs (move the conductor, moving the magnetic field, turning the field off, increasing its strength, etc). The change induces a current in the conductor. The magnetic field of this current opposes the change in the "primary" magnetic field.

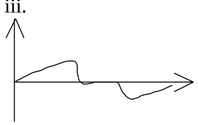
ii.



The field lines of the bar magnet come from its North pole and go to its South pole as shown. The "opposing" field of the solenoid tries to push the magnet back out and so has a N pole at the top.

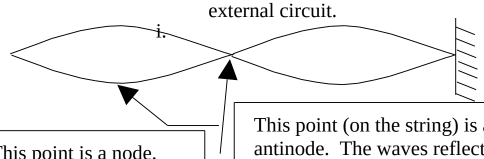
The current in the circuit is "up" as shown since the current must circulate counter-clockwise when viewed from above (RH grip rule, or equivalent).

iii.



The current is proportional to the rate of change of field strength inside the solenoid. This will be greatest when the magnet is entering or leaving the solenoid. While inside the solenoid currents will flow to oppose the falling magnet, but they will be in opposite directions and give no net current in the external circuit.

c) i.



ii.

This point is a node. The reflected waves destructively interfere and the point moves with minimum amplitude (xero).

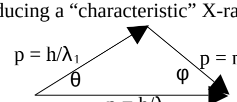
This point (on the string) is an antinode. The waves reflecting off each end constructively interfere and cause the point to have a maximum amplitude of vibration.

The pattern of vibration is called a standing wave because the nodes and antinodes stay in the same position.

iii. The walking people impart energy to the bridge at each step. This sets up a wave that travels in the bridge and reflects off the boundaries of the bridge. Reflections will reinforce (constructively interfere) if the dimensions of the bridge are such that successive reflections are in phase. This bridge had dimensions that coincided with the frequency of natural walking and so the energy imparted by large numbers of people walking in step, set up standing waves having antinodes with large amplitudes. This is a typical example of "resonance".

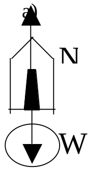
d) i. X-rays are produced when high speed electrons are decelerated at the anode of an X-ray tube. The electrons can change their velocity (accelerate) as they pass a positive nucleus and are attracted towards it. The electrons lose only part of their energy and a lower energy X-ray results. Electrons can collide with the nucleus and give up all their energy, corresponding to an X-ray with maximum energy (maximum frequency, minimum wavelength) or can collide with an electron in an atom of the anode. This latter process does not directly generate an X-ray, but merely ejects the target electron and creates a vacancy in the atom's electron structure. A third electron from somewhere in the anode falls into this vacancy producing a "characteristic" X-ray.

ii.



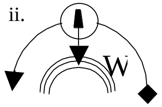
iii. λ_1 is larger than λ_0. The momentum (size) of the incident photon is larger than the momentum of the scattered photon. Notionally it is the same photon, proceeding with less energy, lower frequency and hence greater wavelength, since λ =speed/f. This is the evidence discovered by Compton, showing that X-ray photons scattered by this process display similar scatter patterns to particles.

11. a) i.



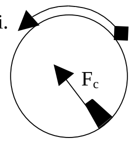
The apparent weight of the tourist is the upward force that they feel in the opposite direction to gravity, in other words the normal force, N. N must be larger than W (weight) so that the net force is upwards, to accelerate the tourist away from the earth.

ii.



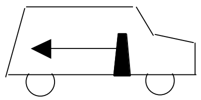
The only force acting on the tourist is their weight, W. Since the space station and the tourist have no potential to move relative to one another, there is no force from the chair to the tourist. Normal force is zero, so the tourist feels "weightless".

iii.



Gravitational forces have the same effect on the tourist as they have on the space station, so they can be ignored. Since the station is rotating the tourist has a centripetal force. This force is provided by the chair and is felt as an apparent weight, greater than zero.

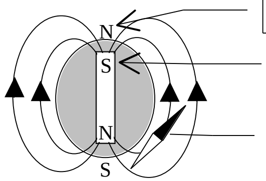
b) i.



There is only one horizontal force, that exerted by the seat-belt on the passenger.

ii. The passenger not wearing the seatbelt has no horizontal force acting, and so in accordance with Newton's First Law moves in a straight line at constant speed. This situation will change when the passenger makes contact with the windscreen which will exert a force and change the passenger's velocity.

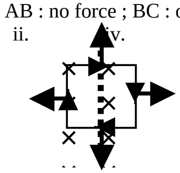
c) i.



ii. "dip angle" or "angle of magnetic declination" is the angle below the horizontal that a compass needle makes when suspended on an east-west horizontal axis in the northern hemisphere. In the southern hemisphere dip angle is above the horizontal and is given a negative sign.

d) i. AB : no force ; BC : out of page ; CD : no force ; DA : into page

ii. iv.



iii. No, the coil will not move (the magnetic field is uniform, as implied by the spacing of the crosses), as all forces combine to give zero resultant force.