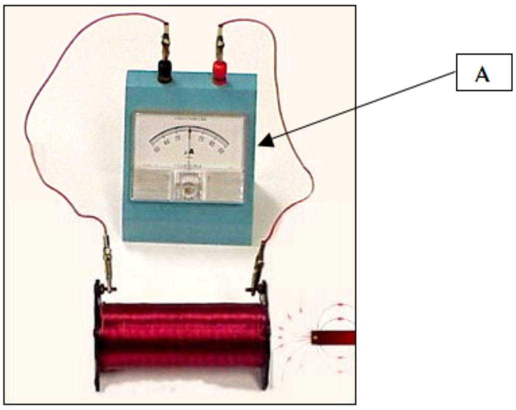
Teachers: Mr Coombes, Mr Pitt, Mr Robson

Task Weighting: 30% **Time Allowed: 1.5 hours**

This task is marked out of 50 marks ____ / 50

INSTRUCTIONS: Read the whole of each question before commencing it, and then record your answers in the spaces provided.

1. Using the apparatus below, an investigation was carried out by moving a magnet slowly into a solenoid and then stopping.



(a) Identify the component labelled A. 1 M

....

(b) Describe TWO observations that could be made when the experiment was performed 2 M

....

....

....

....

....

(c) When analysing these results, a student suggested that this experiment demonstrated the motor effect. Do you agree? Justify your answer with reference to the observations outlined in part (b) and your knowledge of the relevant theory. 3 M

....

....

....

....

....

....

....

....

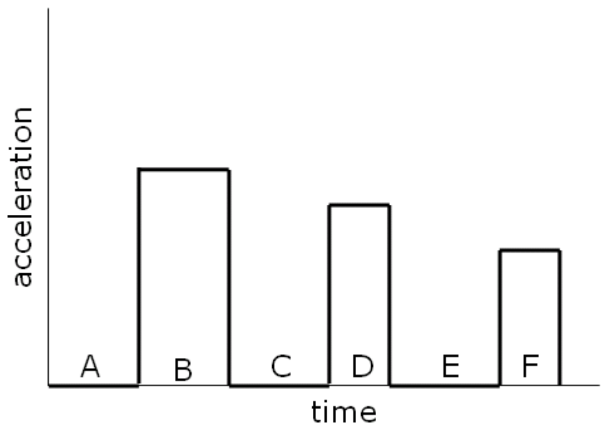
(d) Describe a change to one variable in this investigation that would produce a greater current. 1 M

....

....

....

2. The graph below illustrates how the acceleration of a bus, which is moving in a straight line along a very smooth road, changes with time. Both axes begin at zero.



(a) Compare the motion of the bus in time interval A with its motion in time interval E. 2 M

....

....

....

(b) A passenger on board the bus (obviously a physics tragic:) performed a simple experiment by holding a mass hanging from a string out in front of her. She noticed that, during a particular time interval, the mass swung in the opposite direction to the motion of the bus.

(i) Identify ONE time period on the graph during which she could have made this observation. 1 M

....

....

(ii) Assess the value of this observation in determining whether the passenger was in an inertial or non-inertial frame of reference. 3 M

....

....

....

....

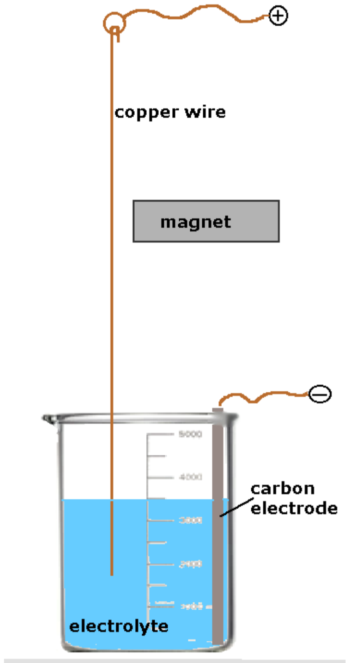
....

....

....

....

3. A straight piece of copper wire was suspended as shown from a support that allowed it to move freely. The lower end was dipped into a conductive solution (electrolyte) in a beaker. A DC voltage source was connected to complete a circuit containing the carbon electrode dipped in the electrolyte. The south end of a magnet was placed near the wire.



(a) Describe the initial response of the wire when the current is turned on. 3 M

....

....

....

(b) Propose two changes, either of which could be made so that the direction of the force produced on the wire when the current was turned on was in the opposite direction to that in part (a). 2 M

....

....

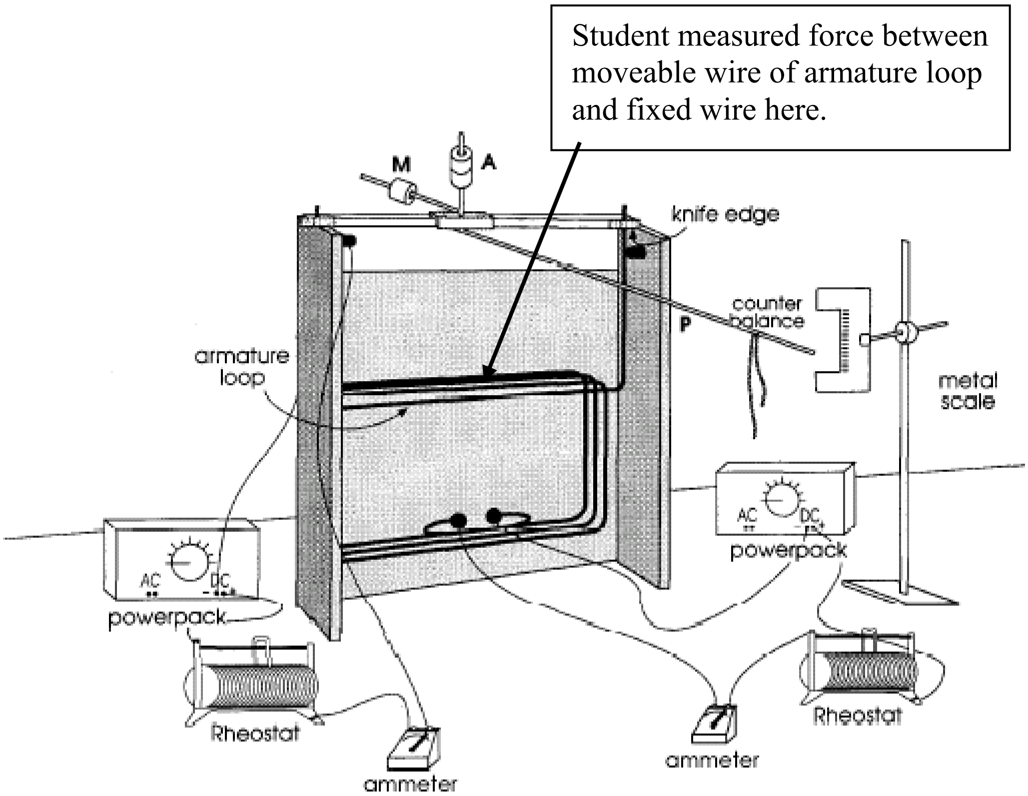
(c) Propose a method of increasing the force on the wire. 1 M

....

....

....

4. The current balance (see diagram below) is used effectively to investigate the magnetic force between 2 current-carrying wires. It consists of a wooden structure holding a fixed square loop of wire and a balancing armature to hold another loop of wire at varying distances from the fixed one. When these two loops are connected in two separate circuits and the current in each circuit turned on, the armature including the single loop is caused to move. The distance moved is a measure of the magnetic force between the loops.



A student wished to establish the relationship between the distance between two parallel current-carrying wires and the magnetic force between them using a current balance. She set up the equipment as shown in the diagram above. She sent identical currents through the fixed and moveable loops, and calculated the size of the magnetic force between the wires. She then varied the initial distance between the loops, making measurements of the magnitude of the magnetic force for each separation. Her results are recorded in the table below:

Distance separating Loops (cm)	Magnetic Force (N)	
1.0	**1.6×10^{-5}**	
1.5	**1.1×10^{-5}**	
2.2	**7.2×10^{-6}**	
3.5	**4.6×10^{-6}**	
5.0	**3.2×10^{-6}**	

(a) Identify the independent variable in this investigation. 1 M

....

(b) A student proposed that these results suggest that the magnetic force is inversely proportional to the distance separating the wires. On the grid below, plot a graph that tests whether this proposal is correct. 2 M

(c) Was the student correct? Justify your answer with reference to your graph. 2 M

....

....

....

....

5. This photo records the motion of a skier who skied off the edge of a cliff in Chamonix in France.

The vertical distance fallen between the first and the last images was 50 metres.

(a) Account for the main features of the skier's trajectory 4 M

....

....

....

....

....

....

....

....

(b) Calculate the time it would take the skier to fall a vertical distance of 50 m. 2 M

....

....

....

....

(c) Consider this statement made about the skier by a person who analysed a section of a movie of the falling skier.

"The time interval covered by this series of images is 3.2 seconds"

(i) Assess this statement. 2 M

....

....

....

....

....

....

(ii) Using the time value quoted in the statement, calculate the time interval between successive images. 1 M

....

....

(d) Predict the final velocity of the skier at the time of the last image on the photograph. 3M

....

....

....

....

....

....

....

....

....

....

....

....

....

6. Mercury, the planet closest to the Sun, has an average orbital radius of 0.387 astronomical units (1 au is the average distance from the Earth to the sun) and an orbital period of 88 Earth days. Uranus is much further from the Sun, having an orbital radius of 19.18 au.

(a) Calculate the orbital period of Uranus in Earth years. 2 M

....

....

....

....

....

....

(b) Calculate the mass of the Sun. 2 M

....

....

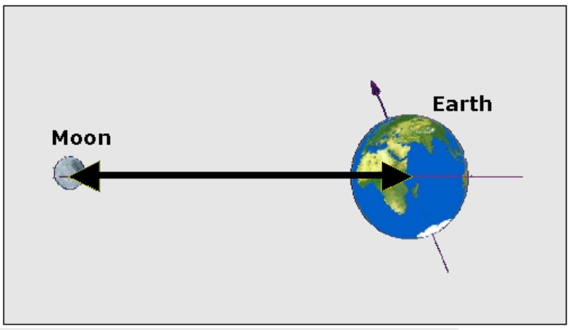
....

....

....

....

7. The Moon orbits the Earth's at an average distance of 384 402 kilometres from the Earth's centre.



Calculate the Moon's orbital velocity. 3 M

....

....

....

....

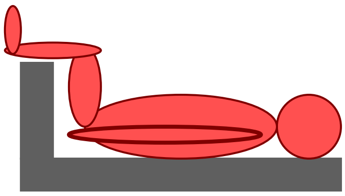
....

....

....

8. The simplified diagram below shows an astronaut in his chair during the vertical stage of a shuttle launch from the surface of the Earth.

(a) On the diagram, clearly indicate the forces acting on the astronaut and their relative magnitudes 2 M



(b) A common term used to describe what an astronaut feels during launch is g-force. G-forces are measured in units of gravitational acceleration, or a person's apparent weight, expressed as a multiple of their weight when at rest on the Earth's surface.

The g-force experienced by the astronaut when the rocket is accelerating vertically from the Earth's surface is given by

$$\frac{9.8 + a}{9.8}$$

where 'a' is the acceleration of the rocket and '9.8' is the value of the acceleration due to gravity, 'g'.

With reference to the forces identified in part (a) and any other relevant formula, derive the expression

$$\frac{9.8 + a}{9.8}.$$

3 M

....

....

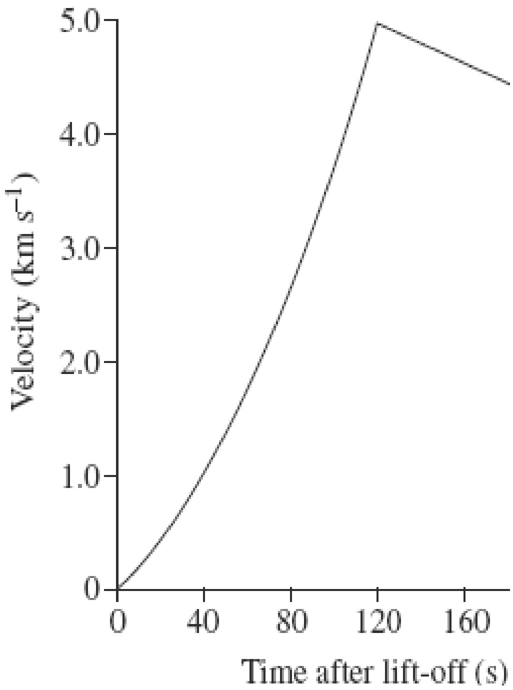
....

....

....

....

(c) The graph below shows how the velocity of the rocket changed with time after lift off.



Data
mass of the Moon = 7.35 x 10^{22} kg
mass of the Earth = 5.98 x 10^{24} kg

Identify the time period in which the astronaut would experience the greatest g-force. Justify your answer with reference to the graph. 2 M

....

....

....

....

....

....

....

Marking Criteria Yr 12 Prac/Process Half yearly 2006

Question 1 (a)

Criteria	Mark/s
Identifies the component as a galvanometer or microammeter	1

Question 1 (b)

Criteria	Mark/s
Presents two relevant observations e.g. a reading was produced on the meter while the magnet was moving and the reading on the meter returned to zero when the magnet stopped moving. NB The observation must relate explicitly to the movement described in the question – movement of the galvanometer needle is in one direction only and then it returns to zero when the magnet stops.	2
One relevant observation presented	1

Question 1 (c)

Criteria	Mark/s
Clearly identifies that the experiment **does** demonstrate the motor effect and provides a thorough explanation of why this is the case, making a valid link between the observations and theory. The meter utilises the motor effect in its operation and this is the best point to discuss. An argument could be presented that both the motor and generator effect rely on the same underlying principle (a force is produced on a charge that moves across magnetic field lines) but this needs to be very clearly explained to get 3 marks.	3
Identifies that the experiment does demonstrate the motor effect and provides an explanation of why this is the case without making a clear link between the observations and motor principle.	2
Describes the motor effect	1

Question 1 (d)

Criteria	Mark/s
Identifies a relevant variable and describes what would need to happen to the variable to increase the current e.g. move the magnet faster, use a stronger magnet	1

Question 2 (a)

Criteria	Mark/s
Clear comparison outlining one correct similarity (eg velocity of bus is constant in both time intervals) and one correct difference (eg. velocity of bus is greater at E than A)	2
Outlines one correct similarity OR one correct difference	1

Question 2 (b) (i)

Criteria	Mark/s
Correctly identifies a time period when the bus is accelerating (B, D or F)	1

Question 2 (b) (ii)

Criteria	Mark/s
Response includes a reasonable judgement of the value of the observation (ie very important, essential) and displays a thorough understanding of the distinction between an inertial and a non-inertial frame of reference, correctly concluding that the motion of the pendulum shows the reference frame is non-inertial	3
Response includes a reasonable judgement of the value of the observation (ie very important, essential) and displays a reasonable understanding of the distinction between an inertial and a non-inertial frame of reference without correctly concluding that the motion of the pendulum shows the reference frame is non-inertial OR Response does not include a correct judgement but displays a reasonable understanding of the distinction between an inertial and a non-inertial frame of reference, correctly concluding that the motion of the pendulum shows the reference frame is non-inertial.	2
Response outlines the distinction between an inertial and a non-inertial frame of reference OR Response makes a reasonable link between the observation and non-inertial frames of reference.	1

Question 3 (a)

Criteria	Mark/s
Correctly states that the wire **moves / out of the page / perpendicular to the direction of B or I** NB this is a 3-mark question and the answer for 3 marks needs to reflect this fact!	3
States that the wire **moves out of the page**	2
States that the wire **moves**	1

Question 3 (b)

Criteria	Mark/s
Correctly identifies two changes that reverse the direction of the force (eg change direction of I and change the polarity of the magnet)	2
Correctly identifies one change	1

Question 3 (c)

Criteria	Mark/s
Correctly identifies one method (eg increase the size of the current, increase the strength of the magnetic field)	1

Question 4 (a)

Criteria	Mark/s
Correctly identifies the independent variable as the distance separating the loops	1

Question 4 (b)

Criteria	Mark/s
Plots a graph of magnetic force against the inverse of distance and draws a reasonable graph (axes labelled with quantity and units, points plotted correctly, reasonable scale, line of best fit drawn)	2
Incorrect graph plotted but drawn well Or correct graph but poorly drawn	1

Question 4 (c)

Criteria	Mark/s
Identifies that the student was correct because the graph is a straight line	2
Identifies that the student was correct but does not provide the appropriate justification.	1

Question 5 (a)

Criteria	Mark/s
Gives reasons for (1) the constant horizontal	4

velocity (or equal distances travelled in equal times) – no net force acting in the horizontal direction and (2) increasing vertical velocity (or increasing distances covered in equal times) – the vertical force of gravity provides as net force in the downward direction that causes the skier to accelerate.	
Gives reasons for one of: the constant horizontal velocity (or equal distances travelled in equal times) and increasing vertical velocity (or increasing distances covered in equal times)	3
Observes that the horizontal velocity is constant (equal distances travelled in equal times) and the vertical velocity is increasing (or increasing distances covered in equal times) OR provides one of these observations and an explanation for it.	2
Makes a valid observation about the trajectory, which could include the statement that it appears to be parabolic.	1

Comment: Many students correctly observed that the horizontal motion was constant and the vertical motion was increasing but did not apply the definition of the verb "Account" and hence failed to provide any reasons.

Question 5 (b)

Criteria	Mark/s
Shows the correct answer with units (3.19 s or 3.2 s)	2
Substitutes the correct values into the appropriate formula ($\Delta y = u_y t + \frac{1}{2} a_y t^2$) OR Has correct answer but no units	1

Question 5 (c) (i)

Criteria	Mark/s
Makes the judgement that the statement is consistent with the calculated time within an acceptable limit and concludes that the statement is correct OR Concludes that the statement is incorrect based on a WRONG answer to part (b).	2
Presents a poorly reasoned argument that the statement is correct.	1

Question 5 (c) (ii)

Criteria	Mark/s
Calculates the correct time interval as 0.23 s (or 0.229 s) [NOTE that 0.21 s or 0.213 s is NOT correct as a division by 15 rather than 14 has produced these answers.	1

Question 5 (d)

Criteria	Mark/s
Calculates the final velocity (33 m s^{-1}) from the vertical and horizontal components of the velocity and states the angle to the vertical or shows the angle qualitatively on a diagram.	3
Draws a vector diagram identifying horizontal and vertical components of the velocity.	2
Calculates only the vertical or horizontal components of the velocity.	1

Question 6 (a)

Criteria	Mark/s
Correct formula chosen with appropriate substitution and correct final answer with units (84.12 years)	2
Correct formula chosen with appropriate substitution but final answer is incorrect or has the wrong units	1

Question 6 (b)

Criteria	Mark/s
Correct formula chosen and a reasonable attempt made to solve the problem given the missing data	2
Correct formula chosen	1

Question 7

Criteria	Mark/s
Correctly links the formula for universal gravitation with the formula for centripetal force to derive an expression for the orbital velocity and Correctly substitutes the values to give a correct final answer including units	3
Correctly links the formula for universal gravitation with the formula for centripetal force to derive an expression for the orbital velocity but does not correctly substitute the values to give a correct final answer including units	2
Identifies that the formula for universal gravitation is required	1

Question 8 (a)

Criteria	Mark/s
Shows the upward force of the seat on the astronaut being greater than the downward weight force	2
Identifies the forces correctly but does not demonstrate that the upward seat force being greater.	1

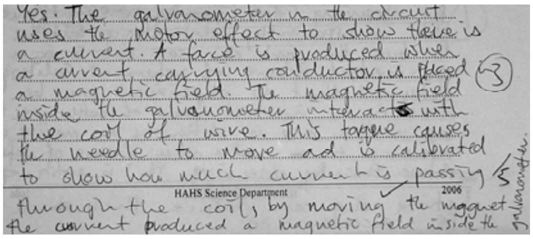
Question 8 (b)

Criteria	Mark/s
Identifies that the net force is the sum of the thrust and the weight forces $\mathbf{F_{net} = ma + mg}$ AND Uses the definition of g force to derive the expression Eg g-force = Apparent Weight / Rest Weight = ma + mg/ mg = a+g/g = a + 9.8/ 9.8	3
Correct derivation of equation but one or more steps not clearly explained. Eg the fact that ma + mg is the net force.	2
Demonstrates some understanding of the concept of g-force	1

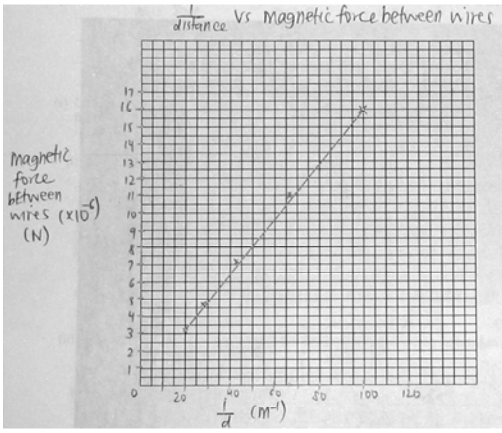
Question 8 (c)

Criteria	Mark/s
Relates the choice of the correct time interval (100-120 s) to the maximum acceleration that is occurring (maximum gradient of graph) and hence the maximum net force that this would need resulting in the maximum g-force	2
Identifies the correct time interval for the maximum g-force but without justification. NOTE : If correct time interval is given but justification is incorrect then 0 marks are awarded.	1

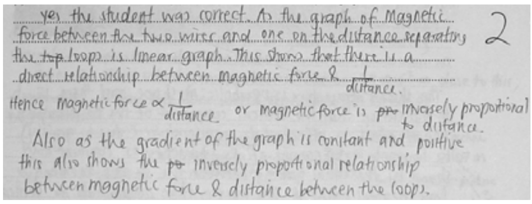
1. (c)


Yes. The galvanometer in the circuit uses the motor effect to show there is a current. A force is produced when a current carrying conductor is placed a magnetic field. The magnetic field inside the galvanometer interacts with the coil of wire. This torque causes the needle to move and is calibrated to show how much current is passing through the coils by moving the magnet the current produced a magnetic field inside the galvanometer.
3

4. (b)



4. (c)


yes the student was correct. As the graph of Magnetic force between the two wires and one on the distance separating the ~~top~~ loops is linear graph. This shows that there is a direct relationship between magnetic force & 1/distance.
Hence magnetic force ∝ 1/distance or magnetic force is ~~pr~~ inversely proportional to distance.
Also as the gradient of the graph is constant and positive this also shows the ~~po~~ inversely proportional relationship between magnetic force & distance between the loops.
2

5. The photo records the motion of a skier who skied off the edge of a cliff…

(a) Account for the main features of the skier's trajectory **4 M**

Assuming that the time between each image is a constant…

The distance covered horizontally is the same in each time interval because there is no horizontal net force acting on the skier.

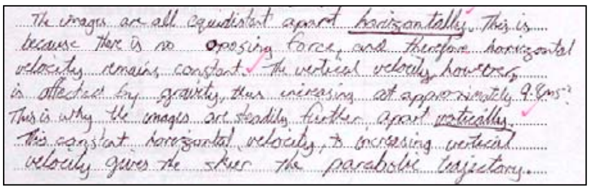
Gravity does not affect the horizontal motion off the skier.

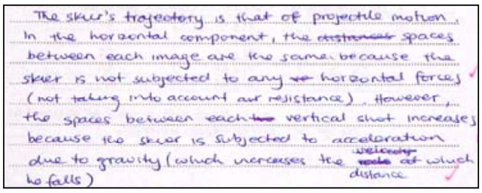
The distance moved in the vertical direction increases for each time interval shown because the force produced by gravity on the skier in the downward direction causes the skier to accelerate in that direction.

Additional comments [not required in the answer]

The effect of air resistance would be negligible over this distance because the skier is relatively dense and massive (large inertia) and he has a surface area that would not result in air resistance providing a force significant enough to affect his motion.

The trajectory appears to be parabolic and this is consistent with the two features described above.


The images are all equidistant apart horizontally. This is because there is no opposing force, and therefore horizontal velocity remains constant. The vertical velocity however, is affected by gravity, thus increasing at approximately 9.8 ms⁻². This is why the images are steadily further apart vertically. This constant horizontal velocity, & increasing vertical velocity gives the skier the parabolic trajectory.


The skier's trajectory is that of projectile motion. In the horizontal component, the ~~distances~~ spaces between each image are the same, because the skier is not subjected to any ~~ve~~ horizontal forces (not taking into account air resistance). However, the spaces between each ~~two~~ vertical shot increases because the skier is subjected to acceleration due to gravity (which increases the ~~velocity~~ ~~rate~~ distance at which he falls)

(b) Calculate the time it would take the skier to fall a vertical distance of 50 m. **2 M**

$\Delta y = u_y t + \frac{1}{2} a_y t^2$

$50 = 0 + (0.5 \times -9.8) \times t^2$

$t = 3.19$ s

(c) Consider this statement made about the skier by a person who analysed a section of a movie of the falling skier.

"The time interval covered by this series of images is 3.2 seconds"

(i) Assess this statement. **2 M**

The value stated by the person is consistent with the calculated time to within 0.01 s and therefore the statement could be considered to be correct.

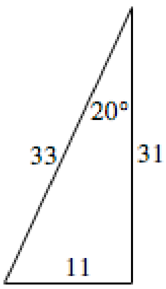
(ii) Using the time value quoted in the statement, calculate the time interval between successive images. 1 M

Number of images = 15 therefore the number of time intervals is 14

Each time interval = 3.2 / 14 = 0.23 s

(d) Predict the final velocity of the skier at the time of the last image on the photograph. 3M

The vertical component of the final velocity is



v = u + at = 0 -9.8 x 3.2 = 31 m s^{-1} (31.36 m s^{-1})

The horizontal component of the velocity is

v_h = horizontal distance / time = 11 m s^{-1}

[This is calculated by using the fact that on the diagram the vertical distance fallen is 136 mm which corresponds to 50 m therefore 82 mm horizontal distance corresponds to 35 m and 35/3.2 = 11]

The magnitude of the final velocity is

33 m s^{-1} (adding components as vectors)

The angle to the vertical is 20° (or 19.5°)

8. (b)

Newton's second law states that the net force on the astronaut must be equal to the astronaut's mass multiplied by his upward acceleration i.e.

F_{net} = ma

The net force on the astronaut is given by

F_{net} = $\sum$Forces = (F_{thrust} + W) = (F_{thrust} + (-mg))

The g-force experienced by the astronaut is the reaction force due to the thrust. Rearranging the preceding equation

F_{thrust} = F_{net} + mg = ma + mg

Now the g-force is expressed as a ratio of the force felt to the reaction force when at rest on the Earth's surface, hence

g-force = F_{thrust} / weight = ((ma + mg) / mg)

i.e. (a + g) / g or (9.8 + a) / 9.8

6. (a)

$$\frac{r_M^3}{T_M^2} = \frac{r_U^3}{T_U^2} \qquad \frac{0.387^3}{88^2} = \frac{19.18^3}{T_U^2}$$

$$T_U^2 = \frac{19.18^3}{0.387^3} \times 88^2 = 30703 \ \ days$$

$$= \ 84 \ \ years$$

6. (b)

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$M = \frac{4\pi^2 r^3}{GT^2}$$ working to include

correct substitution of G and T (in seconds)

8. (c)

The astronaut would experience the greatest g-force is the time period from approximately 80s to approximately 120s. This is the steepest part of the graph and so is the part which experiences the greatest acceleration. Since g-forces are based on the acceleration of the shuttle, and the acceleration is greatest from 80 – 120s, that is the time period in why g-forces are greatest