|  |  |
| --- | --- |
| 9: Mechanics 2  Motion and Newton’s Laws | |
|  | |
| Paper 1 |  |
| 1: Particles 1  Atomic Structure and the SNF | 1. Displacement, speed, velocity, acceleration. 3. Calculations may include average and instantaneous speeds and velocities. 4. Representation by graphical methods of uniform and non–uniform acceleration. 5. Significance of areas of velocity–time and acceleration–time graphs and gradients of displacement–time and velocity–time graphs for uniform and non-uniform acceleration eg graphs for motion of bouncing ball. 6. Equations for uniform acceleration: 7. Acceleration due to gravity, *g*.   **Required practical 3:** Determination of *g* by a freefall method.   1. Independent effect of motion in horizontal and vertical directions of a uniform gravitational field. Problems will be solvable using the equations of uniform acceleration. 2. Qualitative treatment of friction. 3. Distinctions between static and dynamic friction will not be tested. 4. Qualitative treatment of lift and drag forces. 5. Terminal speed. 6. Knowledge that air resistance increases with speed. 7. Qualitative understanding of the effect of air resistance on the trajectory of a projectile and on the factors that affect the maximum speed of a vehicle. 8. Knowledge and application of the three laws of motion in appropriate situations. 9. for situations where the mass is constant. |
| 2: Particles 2  Particle Classification |
| 3: Particles 3  Particle Interaction |
| 4: Quantum  Photoelectric, Energy Levels and WPD |
| 5: Waves 1  Wave Basics and Stationary Waves |
| 6: Waves 2  Interference and Diffraction |
| 7: Waves 3  Refraction and Fibre Optics |
| 8: Mechanics 1  Scalars, Vectors and Moments |
| 9: Mechanics 2  Motion and Newton’s Laws |
| 10: Mechanics 3  Momentum and Energy |
| 11: Materials  Hooke’s Law and the Young Modulus |
| 12: Electricity 1  Resistivity and Superconductivity |
| 13: Electricity 2  Series, Parallel and Potential Dividers |
| 14: Electricity 3  Energy, EMF and Internal Resistance |
| 15: Further Mechanics 1  Circular Motion |
| 16: Further Mechanics 2  Simple Harmonic Motion |

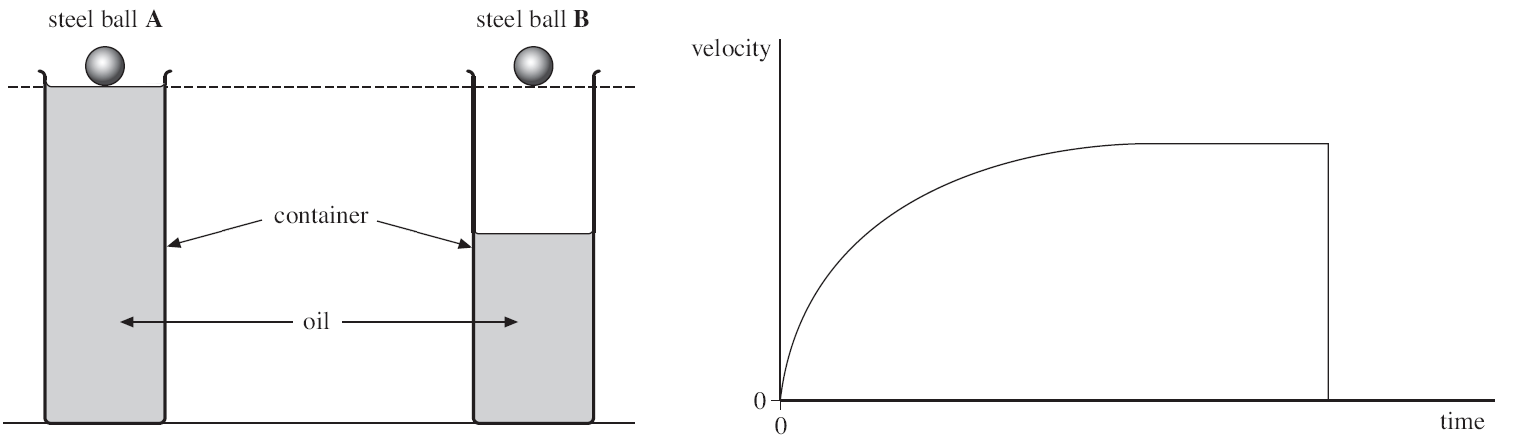
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Monday: Motion Notes**  What is the difference between distance and displacement?  ………………………………………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….………………………………………………………….……………..  What is the difference between speed and velocity?  ………………………………………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….………………………………………………………….……………..  What does a negative velocity mean? ..…………………….…………….……………………………………………………….………………  Velocity can be calculated using the following equation:  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  What is meant by the term ‘acceleration’?  ……………………………………………………………………….……….………………………………………………………….……………..  ………………………………………………………………….…………….……………………………………………………….………………..  What does a negative acceleration mean? ..…………………….…………….………………………………………………….………………  ………………………………………………………………….…………….……………………………………………………….………………..  Acceleration can be calculated using the following equation:  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  What is meant by the following terms?  Uniform acceleration ………………………………………………....…….………………………………………………………………………..  ………………………………………………………………………...……….……………………………………………………………………….  **Displacement-Time Graphs**  What does the gradient represent? …………………………………………………………..…….……………………………………………...  Sketch a displacement-time graph to represent the following:   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | Stationary | Constant Velocity | Constant Acceleration | Constant Decceleration |   **Velocity-Time Graphs**  What does the gradient represent? …………………………………………………………..…….……………………………………………...  What does the area under the line represent? ……………………………………….……..…….……………………………………………...  Sketch a velocity-time graph to represent the following:   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | Constant Velocity | Constant Acceleration | Constant Decceleration | Non-Uniform Acceleration |   **Acceleration-Time Graphs**  What does the area under the line represent? ……………………………………….……..…….……………………………………………...  Sketch an acceleration-time graph to represent the following:   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | Constant Acceleration | Constant Decceleration | Non-Uniform Acceleration | Non-Uniform Decceleration |   When considering motion there are five key quantities:  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  There are four equations of motion that link the above quantities together:   |  |  | | --- | --- | |  |  | | This equation doesn’t contain …………………. | This equation doesn’t contain …………………. | |  |  | | This equation doesn’t contain …………………. | This equation doesn’t contain …………………. |   These equation can only be used if ………………………………………..……….……………………………………………………..……….  What is meant by the ‘acceleration due to gravity’?  …………………………………………………………………………..…….………………………………………………………………………..  …………………………………………………………………………..…….……………………………………………………………………….. |

**Tuesday: Equations of Motion Exam Questions**

|  |
| --- |
| **Q39.** The figure below shows a rollercoaster train that is being accelerated when it is pulled horizontally by a cable.    **Q39(a)** The train accelerates from rest to a speed of 58ms–1 in 3.5 s. The mass of the fully loaded train is 5800 kg.  **Q39(ai)** Calculate the average acceleration of the train.        answer = ...................................... ms–2 **(2)**  **Q39(aii)** Calculate the average tension in the cable as the train is accelerated, stating an appropriate unit.        answer = ........................................................ **(3)**  **Q39(aiii)** Calculate the distance the train moves while accelerating from rest to 58ms–1.          answer = ............................................. m **(2)**  ***Q39(aiv)*** *The efficiency of the rollercoaster acceleration system is 20%.Calculate the average power input to this system during the acceleration.*          *answer = ..................................... W* ***(3)***  **Q39(b)** After reaching its top speed the driving force is removed and the rollercoaster train begins to ascend a steep track. By considering energy transfers, calculate the height that the train would reach if there were no energy losses due to friction.          answer = ...................................... m **(3)**  **(Total 13 marks)**  **Q40.** In the 1969 Moon landing, the Lunar Module separated from the Command Module above the surface of the Moon when it was travelling at a horizontal speed of 2040 m s–1. In order to descend to the Moon’s surface the Lunar Module needed to reduce its speed using its rocket as shown in **Figure 1**.    **Q40(ai)** The average thrust from the rocket was 30 kN and the mass of the Lunar Module was 15100 kg. Calculate the horizontal deceleration of the Lunar Module.          answer = ............................. m s–2 **(2)**  **Q40(aii)** Calculate the time for the Lunar Module to slow to the required horizontal velocity of 150 m s–1. Assume the mass remained constant.        answer = ................................... s **(2)**  **Q40(b)** The rocket was then used to control the velocity of descent so that the Lunar Module descended vertically with a constant velocity as shown in **Figure 2**. Due to the use of fuel during the previous deceleration, the mass of the Lunar Module had fallen by 53%. The acceleration due to gravity near the Moon’s surface = 1.61 m s–2.    **Q40(bi)** Draw force vectors on **Figure 2** to show the forces acting on the Lunar Module at this time. Label the vectors. **(2)**  **Q40(bii)** Calculate the thrust force needed to maintain a constant vertical downwards velocity.        answer = .................................. N **(2)**  **Q40(c)** When the Lunar Module was 1.2 m from the lunar surface, the rocket was switched off. At this point the vertical velocity was 0.80 m s–1. Calculate the vertical velocity at which the Lunar Module reached the lunar surface.      answer = ............................. m s–1 **(2)**  **(Total 10 marks)** |

**Wednesday: Freefall Extended Writing**

Two identical steel balls are released from rest above cylinders containing oil as shown in the diagram below. The balls travel vertically until they reach the bottom of the cylinder. The graph below is the velocity-time graph for steel ball **A**.



Describe and explain how the motion of steel balls **A** and **B** will differ. Your answer should include:

* How the velocity and acceleration of steel ball **A** and **B** vary with time
* An account of the forces acting and their sizes
* A sketch of the velocity-time graph that would represent the motion of steel ball **B** (you may wish to draw this over the graph above).

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

..................................................................................................................................................................................................

**Wednesday: Motion and Newton’s Laws Definitions**

|  |  |
| --- | --- |
| Area Under the Line | On a velocity-time graph this represents the distance travelled. |
| Third | Newton’s law that states that forces are created in pairs. |
| Friction | A drag force acting between two solids. |
| Height | The vertical distance reached by a projectile. |
| Acceleration | The rate of change of velocity. |
| Displacement | The distance from the starting point in a given direction. |
| Second | Newton’s law that connects the change of velocity with the force acting on an object. |
| Area Under the Line | On an acceleration-time graph this represents the change in velocity. |
| Independent | What horizontal motion is compared to vertical motion. |
| Air Resistance | A drag force that increases as speed does. |
| Uniform | This means acceleration where the velocity changes by the same amount every second. |
| Gradient | On a velocity-time graph this represents the acceleration. |
| Velocity | The rate of change of displacement. |
| Area Under the Line | On a force-time graph this represents the change in momentum. |
| Terminal Speed | The speed reached when the forwards forces equal the backwards forces. |
| Freefall | Another way to describe accelerating due to gravity. |
| Steeper | The line on a distance-time graph would do this if the speed of the object was greater. |
| Normal Reaction | A responsive force perpendicular to a surface. |
| Non-Uniform | This means acceleration where the velocity changes by different amounts every second. |
| Range | The horizontal distance reached by a projectile. |
| First | A Newton’s law. “An object will stay at rest or a constant velocity unless a net force acts”. |
| Area Under the Line | On a force-distance graph this represents the work done. |
| Curve | The line on a distance-time graph would do this if the object started to accelerate. |
| Gradient | On a displacement-time graph this represents the velocity. |

|  |  |  |  |
| --- | --- | --- | --- |
| Acceleration | Air Resistance | Area Under the Line | Area Under the Line |
| Area Under the Line | Area Under the Line | Curve | Displacement |
| First | Freefall | Friction | Gradient |
| Gradient | Height | Independent | Non-Uniform |
| Normal Reaction | Range | Second | Steeper |
| Terminal Speed | Third | Uniform | Velocity |
| **Thursday: Projectiles, Terminal Speed and Newton’s Laws Notes**  How is vertical motion connected to horizontal motion?  ………………………………………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….…………………………………………………………………….…..  **How to find the height reached by a projectile**  1) Resolve the velocity to find the vertical speed.  2) Use SUVAT to calculate the distance from the floor to the point where the object stops moving upwards.  **How to find the range by a projectile**  3) Use SUVAT to calculate the time taken to reach the maximum height reached.  4) Double this time to find the time to hit the ground again.  5) Resolve the velocity to find the horizontal speed.  6) Use to calculate the distance travelled.  Calculate the height reached and range of this projectiles.   |  |  | | --- | --- | | https://app.doublestruck.eu/content/AA_PHYS/HTML/Q/QNSL122_files/img01.jpg |  |   What would happen to these values if air resistance was not negligible?  …………………………………………………………………………..…….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  ………………………………………………………………………..……….………………………………………………………………………..  What happens to the weight of a falling object as its speed increases?  …………………………………………………………………………..…….………………………………………………………………………..  What happens to the air resistance of a falling object as its speed increases?  …………………………………………………………………………..…….………………………………………………………………………..  The weight of an object can be calculated using the equation:  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Define the term ‘terminal speed’ and explain how it is reached.  …………………………………………………………………………..…….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  ………………………………………………………………………..……….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  How could a higher terminal speed be reached? Explain how this works.  …………………………………………………………………………..…….………………………………………………………………………..  ………………………………………………………………………..……….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  …………………………………………………………………………..…….………………………………………………………………………..  Write out Newton’s three laws of motion.  1……………………….……………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….……………………………………………………………….………..  …………………………………………………………………………..…….………………………………………………………………………..  2……………………….……………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….……………………………………………………………….………..  …………………………………………………………………………..…….………………………………………………………………………..  3……………………….……………………………………….…………….……………………………………………………….………………..  ……………………………………………………………………….……….……………………………………………………………….………..  ………………………………………………………………………..……….………………………………………………………………………..  When mass is constant Newton’s second law can represented by the following equation:  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  Symbol Quantity …………………………………………………………………………………………… Units ………………………  What will each car do when the forces start to act on the car if…?   |  |  |  |  | | --- | --- | --- | --- | |  | They were stationary? | They were already travelling to the right? | | |  | …………………………..…….………………  …………………………..…….……………… | …………………………..…….………………  …………………………..…….………… | | |  | …………………………..…….………………  …………………………..…….……………… | …………………………..…….………………  …………………………..…….……………… | | |  | …………………………..…….………………  …………………………..…….……………… | …………………………..…….………………  …………………………..…….……………… | | | The diagram shows two of the forces acting on a descent module as it travels down through the atmosphere.  Explain why this isn’t an example of Newton’s third law.  ………………………………………………………………………..……………..…...…….……….  ……………………………………………………………………………………..….....…….……….  ……………………………………………………………………………………..….....…….……….  ……………………………………………………………………………………………...….………. | | |  | | | | | |

**Friday: Projectiles and Terminal Velocity Exam Questions**

|  |
| --- |
| **Q41.**  A digital camera was used to obtain a sequence of images of a tennis ball being struck by a tennis racket. The camera was set to take an image every 5.0 ms. The successive positions of the racket and ball are shown in the diagram below.    **Q41(a)**  The ball has a horizontal velocity of zero at **A** and reaches a constant horizontal velocity at **D** as it leaves the racket. The ball travels a horizontal distance of 0.68 m between **D**and **G**.  **Q41(ai)**  Show that the horizontal velocity of the ball between positions **D** and **G** in the diagram aboveis about 45 m s–1.          **(3)**  **Q41(aii)**  Calculate the horizontal acceleration of the ball between **A** and **D**.      answer = ...................................... m s–2 **(1)**  **Q41(b)**  At **D**, the ball was projected horizontally from a height of 2.3 m above level ground.  **Q41(bi)**  Show that the ball would fall to the ground in about 0.7 s.          **(3)**  **Q41(bii)**  Calculate the horizontal distance that the ball will travel after it leaves the racket before hitting the ground. Assume that only gravity acts on the ball as it falls.        answer = ...................................... m **(2)**  **Q41(biii)** Explain why, in practice, the ball will not travel this far before hitting the ground.  ..................................................................................................................................................................................................  ..................................................................................................................................................................................................  .................................................................................................................................................................................................. **(2)**  **(Total 11 marks)**  **Q42.** In a castle, overlooking a river, a cannon was once employed to fire at enemy ships. One ship was hit by a cannonball at a horizontal distance of 150 m from the cannon as shown in the figure below. The height of the cannon above the river was 67 m and the cannonball was fired horizontally.    **Q42(ai)** Show that the time taken for the cannonball to reach the water surface after being fired from the cannon was 3.7 s. Assume the air resistance was negligible.    **(2)**  **Q42(aii)** Calculate the velocity at which the cannonball was fired. Give your answer to an appropriate number of significant figures.      answer = ............................ m s–1 **(2)**  **Q42(aiii)** Calculate the vertical component of velocity just before the cannonball hit the ship.      answer = ............................ m s–1 **(2)**  **Q42(aiv)** By calculation or scale drawing, find the magnitude and direction of the velocity of the cannonball just before it hit the ship.          velocity = ............................... m s–1  direction = ...................................... **(4)**  **Q42(bi)** Calculate the loss in gravitational potential energy of the cannonball. The mass of the cannonball is 22 kg.    answer = ................................... J **(1)**  **(Total 11 marks)** |

**Saturday: Motion and Newton’s Laws Checklist**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # |  | I can… | L | K | J |
| 43/4 |  | Define the term displacement and explain the difference between distance and displacement. |  |  |  |
| 45/6 |  | Define the term velocity and explain the difference between speed and velocity. |  |  |  |
| 47/8 |  | Calculate velocity using the velocity equation and rearrange the velocity equation to find the unknown. |  |  |  |
| 49 |  | Explain what a negative velocity means. |  |  |  |
| 50 |  | Define the term acceleration. |  |  |  |
| 51/2 |  | Calculate acceleration using the acceleration equation and rearrange the acceleration equation to find the unknown. |  |  |  |
| 53 |  | Explain what a negative acceleration means. |  |  |  |
| 54-7 |  | Sketch a displacement-time graph to represent stationary, constant speed, constant acceleration and deceleration. |  |  |  |
| 58 |  | Sketch a displacement-time graph for a given journey. |  |  |  |
| 59/60 |  | Sketch a velocity-time graph to represent stationary and constant speed. |  |  |  |
| 61/2 |  | Sketch a velocity-time graph to represent constant acceleration and constant deceleration. |  |  |  |
| 63 |  | Sketch a velocity-time graph to represent non-uniform acceleration. |  |  |  |
| 64 |  | Sketch a velocity-time graph for a given journey. |  |  |  |
| 65/6 |  | Sketch an acceleration-time graph to represent constant acceleration and constant deceleration. |  |  |  |
| 67 |  | Sketch an acceleration-time graph to represent non-uniform acceleration. |  |  |  |
| 68 |  | Sketch an acceleration-time graph for a given journey. |  |  |  |
| 69 |  | Describe the motion represented in any motion graph. |  |  |  |
| 70 |  | Describe what the gradient of a displacement-time graph represents. |  |  |  |
| 71 |  | Describe what the gradient of a velocity-time graph represents. |  |  |  |
| 72 |  | Describe what the area under a velocity-time graph represents. |  |  |  |
| 73 |  | Describe what the area under an acceleration-time graph represents. |  |  |  |
| 74 |  | Calculate a gradient. |  |  |  |
| 75 |  | Draw a tangent at a point on a curve. |  |  |  |
| 76 |  | Calculate the area of regular shapes (rectangles and triangles). |  |  |  |
| 77 |  | Calculate the area of an irregular shape. |  |  |  |
| 78 |  | Identify which suvat quantity is given. |  |  |  |
| 79 |  | Select the appropriate equation of motion. |  |  |  |
| 80 |  | Rearrange the equation of motion to find the unknown. |  |  |  |
| 81 |  | Explain what is meant by the acceleration due to gravity. |  |  |  |
| 82 |  | Sketch and label the set-up needed to find the acceleration due to gravity using light gates. |  |  |  |
| 83 |  | Describe the measurements that need to be taken in required practical 3. |  |  |  |
| 84 |  | Describe ways to decrease the uncertainty in each measurement in required practical 3. |  |  |  |
| 85 |  | Describe the graph that would be drawn and what the gradient would represent in required practical 3. |  |  |  |
| 86/7 |  | Calculate the horizontal component of a velocity and the vertical component of a velocity. |  |  |  |
| 88 |  | Describe the connection between the effect of motion in the horizontal and vertical directions. |  |  |  |
| 89 |  | Identify which suvat quantity is given in the horizontal direction. |  |  |  |
| 90 |  | Identify which suvat quantity is given in the vertical direction. |  |  |  |
| 91 |  | Describe the vertical acceleration of a projectile assuming air resistance is negligible. |  |  |  |
| 92 |  | Describe the horizontal acceleration of a projectile assuming air resistance is negligible. |  |  |  |
| 93 |  | Calculate the maximum height reached by a projectile. |  |  |  |
| 94 |  | Describe the effect air resistance has on the maximum height reached by a projectile. |  |  |  |
| 95 |  | Explain the effect air resistance has on the maximum height reached by a projectile. |  |  |  |
| 96 |  | Calculate the time taken for a projectile to reach its maximum height. |  |  |  |
| 97 |  | Calculate the range of a projectile. |  |  |  |
| 98 |  | Describe the effect air resistance has on the range of a projectile. |  |  |  |
| 99 |  | Explain the effect air resistance has on the range of a projectile. |  |  |  |
| 100/1 |  | Recall examples of drag forces and describe properties of all drag forces. |  |  |  |
| 102/3 |  | Calculate weight using the weight equation and rearrange the weight equation to find the unknown. |  |  |  |
| 104/5 |  | Describe what happens to weight as speed increases and what happens to air resistance as speed increases. |  |  |  |
| 106 |  | Define the term terminal speed (or terminal velocity). |  |  |  |
| 107 |  | Explain how terminal speed (of a parachutist) is reached. |  |  |  |
| 108 |  | Describe the effect of air resistance on terminal speed. |  |  |  |
| 109 |  | Explain the effect of air resistance on terminal speed. |  |  |  |
| 110 |  | Sketch and label a velocity-time graph showing terminal speed. |  |  |  |
| 111 |  | Sketch and label an acceleration-time graph showing terminal speed. |  |  |  |
| 112 |  | Describe Newton’s first law of motion. |  |  |  |
| 113 |  | Explain when to apply Newton’s first law of motion. |  |  |  |
| 114 |  | Describe Newton’s second law of motion. |  |  |  |
| 115 |  | Explain when to apply Newton’s second law of motion. |  |  |  |
| 116 |  | Describe Newton’s third law of motion. |  |  |  |
| 117 |  | Explain when to apply Newton’s third law of motion. |  |  |  |
| 118/9 |  | Calculate force using the force-mass equation and rearrange the force-mass equation to find the unknown. |  |  |  |