**P4.1 How can we describe motion?**

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| **Before** | **Objectives** | **After** |
|  | 1. Apply the following equation to situations where an average speed is involved: speed (m/s) = distance travelled (m) time taken (s) |  |
|  | 2. Distinguish between average speed and instantaneous speed (in effect, an average over a short time interval) for examples of motion where speed is changing. |  |
|  | **3. Understand that the displacement of an object at a given moment is its net distance from its starting point together with an indication of direction.** |  |
|  | 4. Draw and interpret a distance-time **(or displacement-time)** graph for an object that is:a. stationaryb. moving at constant speed**c. moving with increasing or decreasing speed.** |  |
|  | 5. Interpret a steeper gradient of a distance-time graph as a higher speed. |  |
|  | **6. Calculate a speed from the gradient of a straight section of a distance-time graph.** |  |
|  | 7. Draw and interpret a speed-time graph for an object that is:a. stationaryb. moving in a straight line with constant speedc. moving in a straight line with steadily increasing or decreasing speed (but no change of direction). |  |
|  | 8. Understand that in many everyday situations, acceleration is used to mean the change in speed of an object in a given time interval. |  |
|  | 9. Recall that the instantaneous velocity of an object is its instantaneous speed together with an indication of the direction. |  |
|  | **10. Understand that the velocity of an object moving in a straight line is positive if it is moving in one direction and negative if it is moving in the opposite direction.** |  |
|  | 11. Draw and interpret a velocity-time graph for an object that is:a. stationaryb. moving in a straight line with constant speedc. moving in a straight line with steadily increasing or decreasing speed (including situations involving a change of direction). |  |
|  | **12. Calculate the acceleration from the gradient of a velocity–time graph (or from a speed-time graph in situations where direction of motion is constant)** |  |
|  | 13. Calculate acceleration using the equation:acceleration (m/s2) = change in velocity (m/s) time taken (s) |  |

**P4.2 What are forces?**

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| **Before** | **Objectives** | **After** |
|  | 1. Recall that a force arises from an interaction between two objects. |  |
|  | 2. Understand that when two objects interact, both always experience a force and that these two forces form an interaction pair. |  |
|  | 3. In simple everyday situations:a. identify forces arising from an interaction between two objectsb. identify the ‘partner’ of a given force (i.e. the other force of the interaction pair)c. specify, for each force, the object which exerts it, and the object on which it actsd. use arrows to show the sizes and directions of forces acting. |  |
|  | 4. Understand that the two forces in an interaction pair are equal in size and opposite in direction, and that they act on different objects. |  |
|  | 5. Describe the interaction between two surfaces which slide (or tend to slide) relative to each other: each surface experiences a force in the direction that prevents (or tends to prevent) relative movement; this interaction is called friction. |  |
|  | 6. Describe the interaction between an object and a horizontal surface it is resting on: the object pushes down on the surface, the surface pushes up on the object with an equal force, and this is called the reaction of the surface. |  |
|  | 7. Recall that friction and the reaction of a surface arise in response to the action of an applied force, and their size matches the applied force up to a limit. |  |
|  | 8. Use the ideas of friction and reaction to explain situations such as the driving force on vehicles **and walking.** |  |
|  | 9. Use the idea of a pair of equal and opposite forces to explain in outline how rockets and jet engines produce a driving force. |  |

**P4.3 What is the connection between forces and motion?**

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| **Before** | **Objectives** | **After** |
|  | 1. Recall that the energy of a moving object is called its kinetic energy. |  |
|  | 2. Recall that as an object is raised, its gravitational potential energy increases, and as it falls, its gravitational potential energy decreases. |  |
|  | 3. Recall that when a force moves an object, it does work. |  |
|  | 4. Use the equation:work done = force × distance moved in direction of force(joules, J) (newtons, N) (metres, m) |  |
|  | 5. Understand that when work is done **on** an object, energy is transferred to the object and when work is done **by** an object, energy is transferred from the object to something else, according to the relationship: amount of energy transferred = work done (joules, J) (joules, J) |  |
|  | 6. Understand that when an object is lifted to a higher position above the ground, work is done by the lifting force; this increases the gravitational potential energy. |  |
|  | 7. Use the equation:change in gravitational potential energy = weight × vertical height difference (joules, J) (newtons, N) (metres, m) |  |
|  | 8. Understand that when a force acting on an object makes its velocity increase, the force does work on the object and this results in an increase in its kinetic energy. |  |
|  | 9. Understand that the greater the mass of an object and the faster it is moving, the greater its kinetic energy. |  |
|  | 10. Use the equation: kinetic energy = ½ × mass × [velocity]2 (joules, J) (kilograms, kg) ([metres per second]2, [m/s]2) |  |
|  | 11. Understand that if friction and air resistance can be ignored, an object’s kinetic energy changes by an amount equal to the work done on it by an applied force. |  |
|  | 12. Understand that air resistance or friction will cause the gain in an object’s kinetic energy to be less than the work done on it by an applied force in the direction of motion, because some energy is dissipated through heating. |  |
|  | 13. Recall that energy is always conserved in any event or process. |  |
|  | 14. Calculate the gain in kinetic energy, **and the speed**, of an object that has fallen through a given height. |  |