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Area Of Study 1, Motion, Study Notes 4

Vertical Motion

Within the limits of our studies, **vertical motion** is motion in a straight line, and with constant (or “uniform”) acceleration, so if horizontal motion with constant acceleration has been properly understood, all that’s required to grasp this concept is to be aware that “vertical” is perpendicular to “horizontal”. Everything studied to this point in reference to horizontal motion (vector addition and subtraction, constant acceleration formulæ, Newton’s laws of motion etc.) are completely applicable to vertical motion as well.

The reason for which vertical motion is covered under a separate sub-heading is that some basic oversights are often made in the process of solving problems concerning vertical motion:

- Within proximity to the Earth’s surface (where nearly all situations concerning vertical motion are located), there’s **always a constant acceleration acting due to gravity**. The magnitude of this acceleration is considered as being **10ms^{-2}** (for simplicity), **9.8ms^{-2}** (for accuracy) or 9.82ms^{-2} (for being excessively pedantic). Which of these magnitudes to use for the correct solution of any specific problem depends on the textbook or exam paper in which the problem appears. In VCE examinations, always use whichever value is specified in the wording of the problem; otherwise either 10ms^{-2} or 9.8ms^{-2} is acceptable.

- The constant acceleration due to gravity is always in a **downwards** direction. This seems obvious, but becomes especially important when it needs to be vectorially added to another acceleration in order to quantify the overall upwards or downwards acceleration of an object. For example, if a rocket is fired upwards, or a ball is thrown downwards. Usually the acceleration due to gravity is considered as **-**10ms^{-2} or **-**9.8ms^{-2}; the negative value indicating a downwards direction (because something launched in an upwards direction slows down as it rises). Often, however, the acceleration due to gravity is considered as positive (because something dropped speeds up as it falls). The important thing about this is to remember to consider the direction of the acceleration due to gravity correctly **in relation to** any other accelerations experienced by an object in question. It will either be in the same direction, or in the opposite direction. Clearly this has a major influence over the solution to any problem concerning vertical motion.

- When only affected by the acceleration due to gravity, a vertically moving object’s velocity will:
  1. decrease as it rises, and
  2. increase as it falls.

- The vertical motion of an object is often considered as **two separate stages**, or as one movement followed by another. In the example of a ball thrown directly upward:
  1. the stage during which the ball is moving upwards, and
  2. the stage during which the ball is moving downwards.

  In the example of a ball bounced of the ground:
  1. the stage during which the ball is approaching the ground, and
  2. the stage during which the ball is coming back up.

- Assuming there’s no air resistance and launch and landing heights are equal, for an object that moves up and then down, the magnitude of its velocity from the end of its initial impulse, at the start of its trajectory is maximum, and equal in magnitude to its velocity at the end of its trajectory. Hence, the initial velocity of the upwards stage of its motion is equal (in magnitude, but obviously opposite in direction) to the final velocity of the downwards stage. For example, a ball thrown directly upwards lands at the same speed at which it was launched, assuming it lands at the same height from which it was launched and that there’s no air friction.

- Also for an object that moves up and then down, the magnitude of its velocity at the peak of its trajectory is zero. Hence, the final velocity of the upwards stage of its motion is zero, and the initial velocity of the downwards stage of its motion is zero as well.