COMP270
Mathematics for 3D Worlds and Simulations

Week 4 Exercises: Newtonian Mechanics

This worksheet is split into two sections: Part A is a set of "traditional" maths questions to complete without a computer, while Part B involves using computer to answer similar questions. You can complete either section first, or swap between them; you may find that tackling the same topic using a different approach enhances your understanding of it.

Before you start, if you haven't already, you may like to read the PhysicsClassroom article on the Independence of Perpendicular Components of Motion and try the exercises at the bottom of the page.

PART A
Answer the following questions using pen(cil) and (graph) paper.
Pro tip: show your working – diagrams can be helpful!

For the following exercises, unless otherwise stated, assume that the acceleration due to gravity is 9.81m/s^2 acting in the negative y direction (with the y-axis pointing upwards), and there is no air resistance or other force acting on the objects.

Diagram of a general projectile motion set-up
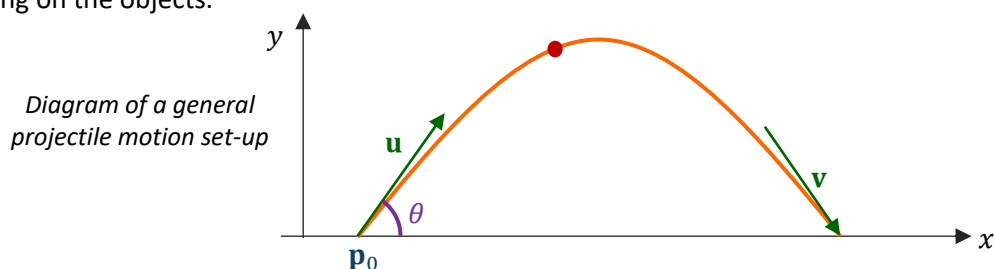
1. A projectile is launched with an initial speed of 30m/s and an angle of inclination θ = 40° from the initial position $\mathbf{p_0} = (0\text{m}, 2.5\text{m})$, i.e. 2.5m above the origin, which is at ground level.

   a. What is the initial velocity $\mathbf{u}$ in vector form?

   b. At what time will the projectile reach its apex (highest point)?

   c. What are the coordinates of the projectile at the apex?

   d. How long will it take for the projectile to come back to an altitude of $y = 2.5$m?

   e. What will the horizontal displacement be at this time?

   f. For how long is the projectile in the air before it hits the ground (y=0)?

   g. Find the values for the projectile's
      i. final velocity, $\mathbf{v}$, and
      ii. final horizontal displacement, s'_x
      when it hits the ground.

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The PhET Projectile Motion simulator is an interactive tool from the University of Colorado that allows you to observe and examine the results of altering projectile parameters (including air resistance, which we haven't considered so you will probably want to switch off, to start with at least).

There is an overview of the interface/modes here; see if you can answer the following questions (as well as verifying your results in part A) by devising and carrying out experiments using it:

1. What effect does the initial speed of an object launched horizontally from an elevation above ground level have on the time it takes to reach the ground?
    Hint: You might find it helpful to use the inspection/measuring tools to analyse results for varying initial speeds.

2. Is it possible to achieve the same range (final displacement) from multiple projection angles? If so, how – or if not, why not?

3. Does the mass of the projectile always influence its trajectory or flight time?