Problem Set 1 (2025) - Issued on 12th June 2025, Solutions Webinar on 18th June 2025

1. A ball of mass $0.1\,\text{kg}$ bounces on a hard surface. Every time it hits the floor, it loses a quarter of its kinetic energy. If the ball is released from a height of $1.00\,\text{m}$, after how many bounces will the ball bounce no higher than $0.25\,\text{m}$?

2. You want to make a snowman out of modelling clay. The snowman consists of two spheres, where one sphere has a radius r, and the other has a radius $2r$. The modelling clay comes in the form of a cylinder with radius $\frac{r}{2}$. What length of modelling clay is required to make the snowman?

3. A mass m is hung from a spring with a spring constant of k. When set into motion, the mass oscillates with a period

$$T = 2\pi\sqrt{\frac{m}{k}}.$$

   Using another identical spring:

   (a) What would be the period of oscillation of the mass if it were taken to a planet with a gravitational field strength of $2g$?

   (b) What would be the period of oscillation of the mass if it were hung from the two springs connected end-to-end (in series)?

   (c) What would be the period of oscillation of the mass if it were hung from the two springs connected side-by-side (in parallel)?

4. A ball is thrown at an angle of $30°$ up from the horizontal, at a speed of $10\,\text{ms}^{-1}$, off the top of a cliff which is $10\,\text{m}$ high above a flat beach. How long does it take for the ball to hit the beach below? You may assume that the acceleration due to gravity is $10\,\text{ms}^{-2}$, and that air resistance can be neglected.

5. I walk down a long street at $1\,\text{ms}^{-1}$ for an hour. During this time I count the number of trams that pass me by. Knowing that they follow a regular

timetable in both directions I am initially surprised to note that only 15 trams overtake me, whereas 20 passed me head on. What is the average speed of the trams?

6. Hayley and Rob offer to paint the outside of our house. Hayley claims she can do the job in 2 days (working continuously). Rob says he'll complete the job in 3 days. If they are both hired to work together, how long should it take?

Hints for Workshop Session 1

1. Remember that gravitational potential energy depends linearly on height above the ground. After each bounce, 75% of the energy remains, so how many times do you need to take 75% of 75% of 75% ... etc. to have only 25% remaining?

2. If the larger sphere has twice the radius, it has eight (2^3) times the volume. Remember that the formula for the volume of a sphere is $V_S = \frac{4}{3}\pi r^3$ and of a cylinder is $V_C = \pi r^2 h$.

3. (a) What changes?
   (b) In this case, each spring experiences the same force of the weight of the mass. What effect does this have on k and therefore T?
   (c) In this case, each spring experiences half the force of the weight of the mass. What effect does this have on k and therefore T?

4. Once the ball has reached its highest point, it is essentially just falling the rest of the time. Remember that you can calculate both the negative and positive displacement using suvat equations.

5. A diagram is very useful; remember to include how far you walk in between each tram passing you.

6. From the information given, consider how much each person can paint in one day.

Numerical answers can be found below.

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Solutions to be discussed in webinar on Wednesday 18th June 2025