Conservation of Energy and Projectile Motion
These questions need to be completed before entering the lab. Show all workings.

**Prelab 1:**
A 500 kg car is at rest at the top of a 50.0 m high hill. Calculate the energy of the car at the top of the hill.

**Prelab 2:**
The car rolls to the bottom of the hill. At the bottom of the hill, the car has a speed of 27.8 m/s. Calculate the energy of the car at the bottom of the hill. (Assume the bottom of the hill has a height of 0 m.)

**Prelab 3:**
Calculate the work done by friction on the car as it rolled down the hill.
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Part I: Introduction

In this lab, you will slide a pointed mass through a track. It will leave the track with an initial velocity and land on a piece of paper.

Using conservation of energy you will predict the velocity with which it emerges from the track. Using measurements of the horizontal distance travelled and the kinematic equations, you will determine the actual speed with which it emerged. You will use energy to determine the work done by friction on the projectile.
Part II: Set up

Assemble your apparatus as shown.

Insert the sheet of carbon paper between two sheets of paper (inky side down) and slide the sheets under the wooden stand.

Secure your paper to the desktop and mark the position of the edge of the stand.

The track is assumed to be horizontal at the bottom.
Part II: Set up
Initial measurements

Measure the height $H$ of the top of the track relative to the table.
Measure the height $h$ of the bottom of the track relative to the table.
Weigh the mass $m$ using a triple beam balance.
The uncertainty in the balance is 0.1 g.
Refer to Experiment 1 to estimate the uncertainty of a metre stick.
Enter these results in Table 1.
Part III: Conservation of Energy

Initial Predictions

QUESTION 1: Draw a free body diagram for the mass while it is on the middle of the track. Label all forces.

QUESTION 2:

a) Write down the equation for the mechanical energy when the mass is at the top of the track (just before it is released). Be careful to use the correct symbols from the diagram on the previous slide.

b) Write down the equation for the energy of the mass as it emerges from the bottom of the track.

c) Do you expect these energies to be the same or different? Explain.

Before proceeding, have an instructor come check your answers and initial your lab report.
Part IV: Projectile Motion

Data Collection

Holding the mass at the top of the track, release it gently from rest.
Mark the landing position on the paper.
Repeat your procedure 8 times, marking the position on the paper each time.
Be sure to release the mass in the same way each time.
Measure the distance from the base of the stand to each landing point.
Record these values in Table 2.
Part IV: Projectile Motion

Data Collection

Use Graphical Analysis to determine the standard error in range:

Click to open Graphical Analysis.

Enter your range values in Graphical Analysis.

Click **Analyze** then **Statistics**.

Record the mean, standard deviation, and number of samples in **Table 2**.

Calculate the standard error and record your result in **Table 2**.
QUESTION 3: Using the range $\bar{R}$ and the height $h$, determine the velocity of the mass as it emerged from the bottom of the track. You may assume air resistance is negligible. Include direction and uncertainty.

Hint: You will need to use kinematics!

You may use the uncertainty equation

$$\frac{\delta v}{v} = \frac{\delta R}{R} + \frac{1}{2} \frac{(\delta h)}{h}$$

QUESTION 4: Determine the mechanical energy of the mass at the top of the track (just before it is released). You may use your results from Question 2.
Part IV: Projectile Motion
Data Analysis

QUESTION 5: Determine the mechanical energy of the mass as it emerges from the bottom of the track.

QUESTION 6: Using these results, determine the work due to friction.

QUESTION 7: If we assume that the track has a length of 0.438 m, determine the average frictional force between the track and the mass.
Part V: Summary

QUESTION 8:

a) Using conservation of energy and your expressions from Question 2, determine the theoretical velocity with which the mass would emerge from the bottom of the track if there were no friction between the mass and the track. Include uncertainty and direction in your answer.

b) Is this value equal to the velocity calculated in Question 3 within the uncertainty? Is this an expected result? Explain.

c) Considering your results, is it reasonable to neglect friction when determining the velocity of the mass emerging from the track? Explain.
Part V: Summary

QUESTION 9: List at least three sources of uncertainty in this experiment. Classify them as random or systematic.

QUESTION 10: Write a brief summary of this experiment.

Be sure to include:

- the details of what was done in the experiment
- how the data was analyzed
- the results of the analysis
- your conclusions from your experiment.
Wrap it up!

Make sure you have completed all tables.

Make sure you have answered all questions.

Include your sheets of paper showing the landing positions of the mass (each partner should have one sheet).