Experiment 10: Impulse and Momentum

Aim:

To investigate the relationship between impulse and momentum.

Theory:

To change an object's motion we need to apply a force for a period of time. This quantity of force x time is known as impulse. For an object experiencing a constant force we can find an equation for impulse by using Newton's Second law (F=ma) and the equations of motion as follows

$$\begin{aligned} I &= Ft = mat \\ &= mv_2 - mv_1 \\ &= \Delta P \end{aligned}$$

Where F is the force acting on the body, ΔP is the change in momentum, m is the mass of the body and v_1, v_2 are the velocities of the body before and after impulse. Note that momentum, force, acceleration and velocity are all vector quantities and so impulse has the same direction as the force that produced it.

In this experiment a trolley collides with a force sensor and the change in momentum is compared to the impulse.

The impulse is found by calculating the area under the force vs time graph (the integral of the force) measured by the sensor.

A photo gate is used to measure the velocities of the trolley before and after the collision.

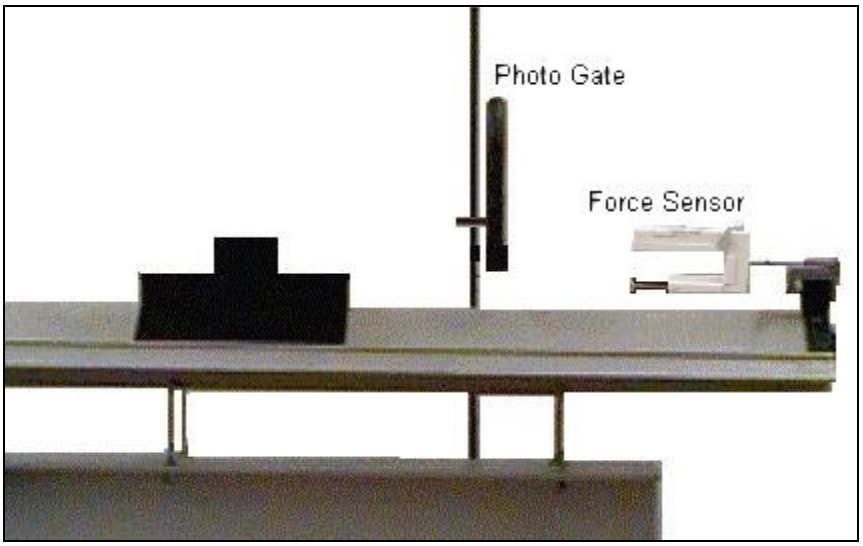
Equipment: Force and photo gate sensors connected to an interface or data logger, linear airtrack and glider (or ramp and dynamics trolley) and a computer.

Data Logger Setup:

- Input 1: Photo Gate
- Input 2: Force Sensor
- Samples: 40000
- Rate: 10000 / Sec

Method:

I. Setup the equipment as shown



II. Connect the data logger or interface to the computer and start the software.

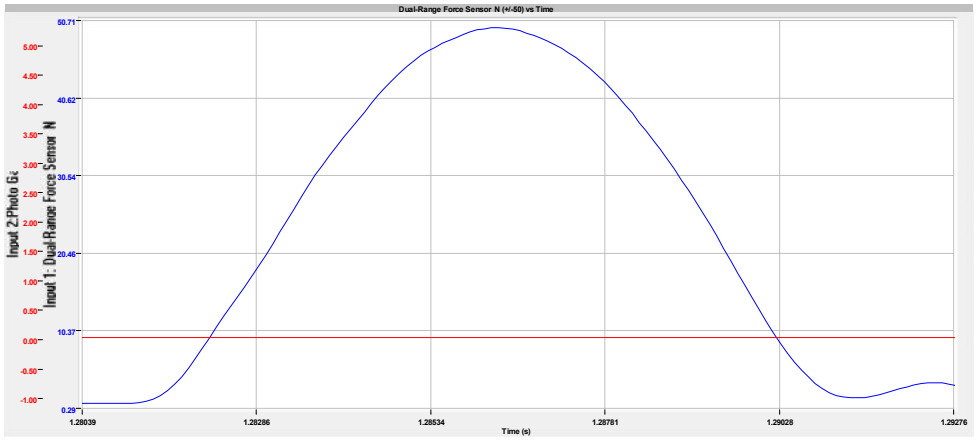
III. Place the glider or trolley on the track as shown in the diagram with a glider flag (10 cm).

IV. Start logging and immediately push the trolley towards the force sensor. Make sure that the initial push is strong enough: after the collision the trolley must pass back through the photo-gate so that its velocity after the collision can be calculated.

V. Measure the mass of the trolley. Record this value.

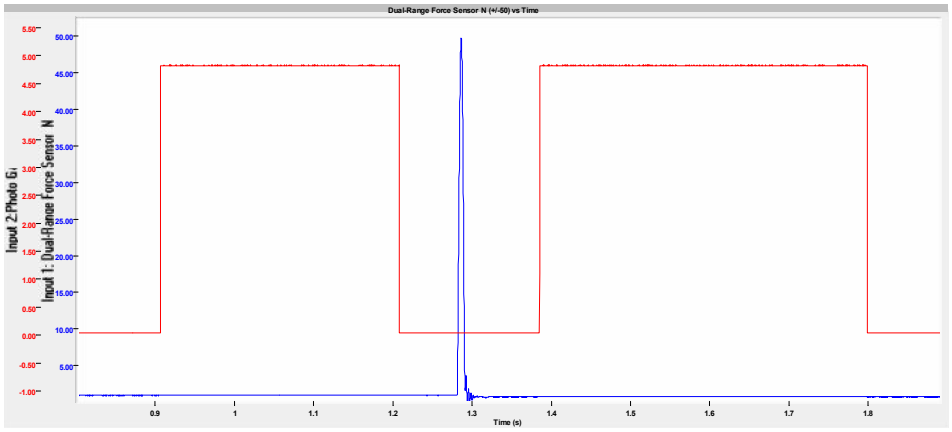
Analysis:

1. Calculate the impulse:
   - Display a graph of force vs time. The area under the curve is the Impulse (see below).



2. Calculate the change in momentum:

   - In the graph created by the photo gate identify the times when the light was blocked by the glider flag (see below)



   - Use cursors to find dt_1 the first time interval during which the light was blocked by the glider flag. Record dt_1.
   - Repeat the above step to measure dt_2 the second time interval when the light was blocked. Record dt_2.
   - Use the length of the glider flag, Δx , and the time intervals dt_1, dt_2 to calculate the velocities of the trolley before and after the impulse:

$$v_1 = \frac{\Delta x}{dt_1} \qquad v_2 = -\frac{\Delta x}{dt_2}$$

Note that as velocity is a vector a negative sign for v_2 indicates opposite direction to v_1.

   - Multiply the velocities by the mass m to calculate the momentum before and after the impulse:

$$p_1 = mv_1 \qquad p_2 = mv_2$$

- Calculate the difference in momentum (remember momentum is a vector):

$$\Delta p = p_2 - p_1$$

- Record this value.

Discussion:

Compare the impulse to the change in momentum

1. Is the change in momentum equal to the impulse?

2. Would the impulse be different if the mass was of the glider was changed? Explain your answer.

3. Discuss any sources of error that may have affected your results.

Conclusion:

Write your own conclusion ensuring that it relates to the aim as stated above.