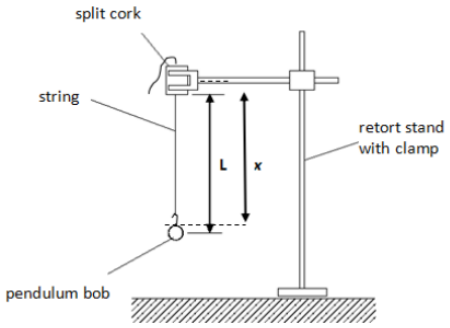
Pendulum Experiment

- **Aim**: To investigate how the **length** of a pendulum, L affects the **period** of oscillation, T.
- **Apparatus**: Stopwatch, string of about 1.000 m, pendulum bob, vernier calipers, metre rule, split cork, retort stand.



Procedure:

1 Using the vernier calipers, measure and record the diameter d of the pendulum bob.
   a. Record also its radius, r.
   Diameter of bob, d = _____ cm
   Radius of bob, r = _____ cm

2 Set up the apparatus as shown in the diagram by clamping the string between the split corks. Adjust the string to a suitable length, with a short section above the split cork. Measure the length x.

3 Determine the length L of the pendulum using the formula L = x + r

4 Gently pull the pendulum bob to one side and release. The pendulum will oscillate from side to side. One complete oscillation refers to the left to right and back to left movement.

5 Record the time taken for 20 oscillations, t_1.

6 Repeat step 5 twice and record readings t_2 and t_3.

7 Calculate the average time, t_{ave}, for 20 oscillations. Calculate the period T, where T is the time taken for the pendulum bob to make one oscillation.

8 Determine value of T^2 for each value of L.

9 Record all readings in table as shown below:

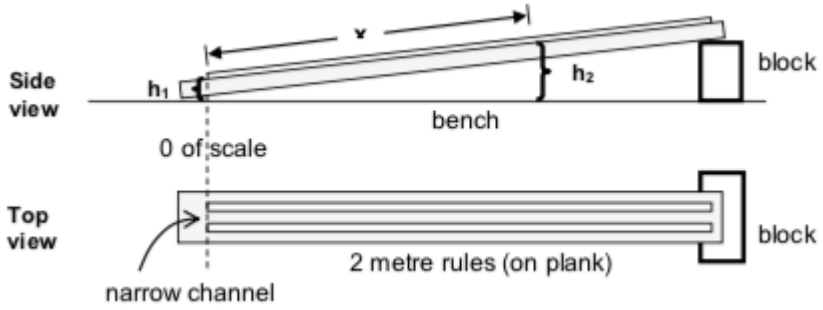
L / ____	time for _____ oscillations / s			T / s	T^2 / ____
	t_1	t_2	t_{ave}		

10 Repeat step 4 – 9 for 4 other values of L, varying the length x of the string.

11 Plot a graph of T^2/s^2 against L/cm and determine the gradient of the graph.

Work, Energy, Power Experiment

- **Aim**: To investigate the relationship between GPE and KE as a marble rolls down the ramp.
- **Apparatus**: marble, metre rule, set-square, small wooden block, stopwatch, masking tape
- **Variables**:
  - Independent variable: length of slope, x
  - Dependent variable: time taken for marble to roll down distance x, t
  - Controlled variable: initial velocity, v_i and angle of inclination, theta



Procedure

1 Set up apparatus as shown in diagram above.

2 Measure and record mass of a marble, m in kg.

3 Measure and record the heights h_1 and h_2 of the underside of the rule above the bench at 0.0 cm and 50.0 cm marks on the metre rules.
   a. h_1 = __ m and h_2 = __ m

4 Ensure that readings were taken when half-metre rule was vertical by using a set-square placed adjacent as shown in diagram below.

5 Release marble from rest at distance x = 50.0 cm and record time taken, t_1 for marble to roll down to the 0.0 cm mark using the stop-watch.

6 Repeat step 5 twice and record reading t_2 and t_3.

7 Calculate average time taken, t_{ave} for marble to roll down the slope from 50.0 cm mark.

8 Calculate
   a. average speed, v of the marble as it rolls down the slope using the formula x/t_{ave}
   b. the maximum speed v as it reaches the bottom given that $v_o = 2\ v$.
   c. the gain in kinetic energy given that $E_k = ½\ mv_o^2$
   d. potential energy lost given that $E_p = mg(h_2 – h_1)$, where $g = 10\ N\ kg^{-1}$

9 Change value of x and repeat steps 3 to 8 for four more sets of data.

10 Record results in a table as shown below.

x / m	Timings / s			$(h_2 - h_1)$ / m	v/ m s^{-1}	v_o / m s^{-1}	E_k / J	E_p / J
	t_1	t_2	t_{ave}					
0.500	2.30	2.33	2.32	0.008	0.216	0.432	0.00049	0.00042
0.600	2.44	2.40	2.42	0.010	0.248	0.496	0.00064	0.00052
0.700	2.52	2.50	2.51	0.014	0.279	0.558	0.00081	0.00073
0.800	2.89	2.64	2.77	0.018	0.289	0.578	0.00087	0.00094
0.900	3.04	2.88	2.96	0.023	0.304	0.608	0.00096	0.0012

11 Plot a graph of E_p against E_k.

12 Determine the gradient and line of best fit.

Relationship between GPE and KE

- GPE is proportional to KE. A linear best fit line with a positive gradient was drawn on the line.
- As GPE is equal to KE + energy lost, fraction of energy lost can be measured using difference of 1 and fraction of KE.
    - $E_{lost} = E_p - E_k$
    - $E_{lost}/E_p = (E_p - E_k)/E_p = 1 – 1/(E_p/E_k)$
    - Fraction of energy lost = 1 – 1/gradient

<u>Improvement</u>

- Use a smooth PVC tube instead of 2 metre rule on a plank.
- Apply a layer of lubricant on rolling marble.