

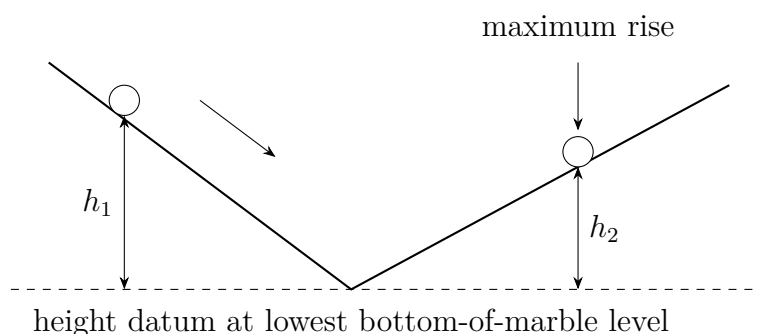
Energy recovery on joined runways

Name: _____ Class: _____ Date: _____

Aim Find how a marble's recovered gravitational potential energy depends on release height. Allow 60 minutes.

Key ideas For the same marble, recovered energy fraction $\eta = \bar{h}_2/h_1$. Percentage recovery is 100η . Measure both heights from one datum. The bottom of the same marble can be used because its radius cancels between equal datum offsets.

Apparatus Two rigid V-groove runways about 40 cm long, two stands and clamps, marble, metre rule, balance and catch tray.



Set the zero height at the bottom of the marble when it is at the lowest point of the joined track. Measure height gains from there. A bench datum is equivalent only when that lowest bottom-of-marble level is at bench height.

Safety Clamp the runways securely. Keep the marble contained and catch any escape with a tray. Pick up fallen marbles immediately to prevent slips.

1 Run the experiment

1. Align the grooves so the marble crosses the join smoothly. Check that the tracks stay fixed and the marble cannot roll off the ends.
2. Measure marble mass m and define the height datum. Choose at least six well-spread release heights h_1 .
3. Place the marble at the first height. Release without a push. Read the greatest height h_2 reached on the second runway.
4. Repeat three times at the same h_1 . One partner releases while the other watches beside the ruler. Alternate roles halfway through.
5. Change h_1 only. Keep the marble, runway angles and join unchanged. Revisit one earlier height to check for drift. Recheck the alignment if the tracks move.

2 Results and energy calculations

$m =$ _____ kg Height datum: _____.

h_1/m	h_{2a}/m	h_{2b}/m	h_{2c}/m	$\bar{h}_2/\text{m}$	$\eta = \bar{h}_2/h_1$

Worked processing frame Choose one row and complete:

$$E_1 = mgh_1 = \text{_____} \quad \text{J}$$

$$E_2 = mg\bar{h}_2 = \text{_____} \quad \text{J}$$

$$\text{Energy not recovered} = mg(h_1 - \bar{h}_2) = \text{_____} \quad \text{J}$$

Uncertainty Estimate Δh_1 and $\Delta \bar{h}_2$. Include judging the turning point and the spread of repeat readings, not only ruler resolution.

Model check Why should $0 \leq \eta \leq 1$ for a release from rest? What would $\eta > 1$ tell you to check?

3 Graph

Plot recovered fraction $\eta = \bar{h}_2/h_1$ against release height h_1 . Draw a best-fit trend supported by the data; do not assume it must be a straight line.



Choose scales and label both axes with quantities and units. Mark a large gradient triangle on the best-fit line where appropriate.

4 Interpret energy recovery

1. Is recovery fraction constant, increasing or decreasing with release height? Use numerical values and the pattern on your graph.

2. Estimate $\Delta\eta/\eta \approx \Delta\bar{h}_2/\bar{h}_2 + \Delta h_1/h_1$ for two contrasting rows. Is the apparent trend larger than the uncertainties?

3. Explain why rotational kinetic energy is not automatically “lost energy”. For rolling without slipping, translation and rotation stop together at maximum rise; identify mechanisms that transfer mechanical energy to the surroundings.

4. Identify two limitations of measuring a moving marble’s maximum height. Give an improvement for each and explain how it helps.

5. Plan a further comparison using a different runway angle. State what to change, measure and keep constant.

Conclusion Give the recovered fraction over your tested height range and qualify any trend that is not clear within uncertainty.

Before you leave Return the apparatus, clear the bench and submit your recorded data.