3.3 Work and energy

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS work • potential energy • spring constant

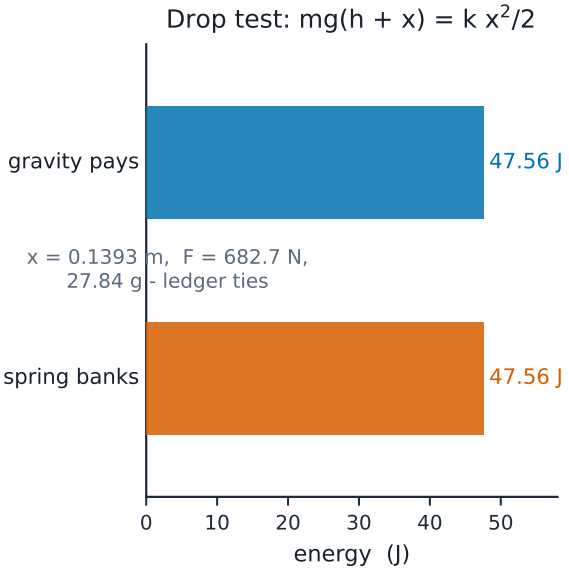
Objective

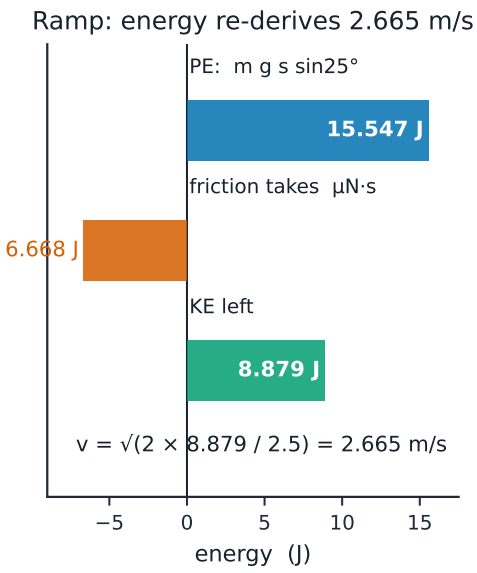
Close an energy ledger: gravity pays, springs bank, friction burns - and both sides tie to the joule.

1 Key knowledge and worked examples

■ The ledger

$T_1 + V_1 + U_{1\to 2} = T_2 + V_2$; gravity mgh, springs $\frac{1}{2}kx^2$, friction $-\mu_k N s$. The drop test keeps the $+x$: gravity works through the deflection.





*Both ledger sides must tie

■ Worked example. The drop test

$mg(h + x) = \frac{1}{2}kx^2$ with $k = 4900$, $h = 1.80$ m: $x = 0.1393$ m, $F = 682.7$ N, 27.84 g, and 47.56 J = 47.56 J ✓.

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2 Practice

A 3.0 kg module in its mount ($k = 3600$ N/m) is drop-tested from $h = 1.20$ m onto the certified floor.

2.1 The energy balance equation with the $+x$ term explained, and the maximum deflection (metres, four significant figures). [4]

2.2 The peak force and the peak deceleration in g (one decimal for the force, two for the g-load). [3]

2.3 The same module slides 2.00 m down the 20° ramp of sheet 3.2 ($\mu_k = 0.25$). The potential energy released, the friction work, and the speed at the end (three decimals). [4]

2.4 One sentence: why does halving the drop height NOT halve the peak force? [2]

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Solutions

2.1

- $mg(h + x) = \tfrac{1}{2}kx^2$ - gravity keeps working through the deflection x.
- $1800x^2 = 29.43(1.20 + x)$ gives $x = 0.1485$ m.

2.2

- $F = kx = 3600 \times 0.1485 = 534.5$ N.
- $534.5/(3.0 \times 9.81) = 18.16$ g.

2.3

- Released: $mgs\sin 20° = 3.0 \times 9.81 \times 2.00 \times 0.342 = 20.13$ J.
- Friction: $0.25 \times 29.43 \times \cos 20° \times 2.00 = 13.84$ J.
- $KE = 20.13 - 13.84 = 6.30$ J, so $v = \sqrt{2 \times 6.30/3.0} = 2.049$ m/s.

2.4

- Gravity supplies $mg(h+x)$: halving h halves only part of the payment, and x shrinks less than proportionally.

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