Year 11 Science: Kinetic energy, potential energy and work

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. Calculate the kinetic energy of a 1200 kg car travelling at 15 m/s.

2. A 0.5 kg book is lifted from the floor onto a shelf 1.8 m high. How much Ep does it gain?

3. A shopper pushes a trolley 25 m along an aisle with a force of 80 N. How much work is done?

4. A diver steps off a 5.0 m platform. Ignoring air resistance, how fast is she going when she reaches the water?

5. A 55 kg student runs up stairs with a total height of 12 m in 20 s. Find the Ep gained and her power.

Exam-style question: the playground slide

Aroha has a mass of 40 kg. She climbs to the top of a playground slide 2.5 m above the ground and slides down from rest. Use g = 10 N/kg.

6. Describe the energy changes as Aroha goes down the slide.

7. Calculate the greatest speed Aroha could have at the bottom, and state the assumption you made.

8. Her real speed at the bottom is 6.0 m/s. Discuss what happened to the rest of her energy, using calculations, and explain why the slide feels slightly warm afterwards.

Fix the mistake

9. Correct this statement: "$v^2 = 64$, so the apple lands at 64 m/s."

10. Correct this statement: "Energy is lost when the object hits air resistance, so the total energy goes down."

11. Correct this statement: "A 500 g ball dropped 2 m has Ep = 500 × 10 × 2 = 10 000 J."

12. Correct this statement: "Doubling the speed doubles the kinetic energy."

Answer key (for parents and tutors)

1. Calculate the kinetic energy of a 1200 kg car travelling at 15 m/s.
   $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 1200 \times 15^2 = 135\,000$ J.

2. A 0.5 kg book is lifted from the floor onto a shelf 1.8 m high. How much Ep does it gain?
   $E_p = mgh = 0.5 \times 10 \times 1.8 = 9$ J.

3. A shopper pushes a trolley 25 m along an aisle with a force of 80 N. How much work is done?
   $W = Fd = 80 \times 25 = 2000$ J.

4. A diver steps off a 5.0 m platform. Ignoring air resistance, how fast is she going when she reaches the water?
   All Ep becomes Ek, so $v = \sqrt{(2gh)} = \sqrt{(2 \times 10 \times 5.0)} = \sqrt{100} = 10$ m/s.

5. A 55 kg student runs up stairs with a total height of 12 m in 20 s. Find the Ep gained and her power.
   $E_p = 55 \times 10 \times 12 = 6600$ J; $P = E \div t = 6600 \div 20 = 330$ W (assuming all her work goes into Ep).

6. Describe the energy changes as Aroha goes down the slide.
   Gravitational potential energy is transformed into kinetic energy as she loses height and gains speed, and some becomes thermal energy and sound because of friction (Achieved).

7. Calculate the greatest speed Aroha could have at the bottom, and state the assumption you made.
   $E_p = mgh = 40 \times 10 \times 2.5 = 1000$ J. Assume all the Ep becomes Ek (no friction or air resistance): $1000 = \frac{1}{2} \times 40 \times v^2$, so $v^2 = 50$ and $v = 7.1$ m/s. Full working earns Merit; the correct unit and the stated assumption are needed for Excellence.

8. Her real speed at the bottom is 6.0 m/s. Discuss what happened to the rest of her energy, using calculations, and explain why the slide feels slightly warm afterwards.
   Real $E_k = \frac{1}{2} \times 40 \times 6.0^2 = 720$ J, so $1000 - 720 = 280$ J did not become Ek (Merit for the calculation and naming friction). Excellence links it all: friction between her clothes and the slide makes the particles at both surfaces vibrate faster, raising their temperature, and she also pushes air particles aside; that 280 J is transferred to the slide, her clothes and the air as thermal energy and sound. Energy is conserved ($720 + 280 = 1000$ J), but only 72% of the Ep became Ek, so she reaches 6.0 m/s instead of 7.1 m/s.

9. Correct this statement: "$v^2 = 64$, so the apple lands at 64 m/s."
   That is v^2, not v; take the square root to get $v = 8$ m/s, a step markers often see missed.

10. Correct this statement: "Energy is lost when the object hits air resistance, so the total energy goes down."
    Energy is never lost; it is transferred to the air as thermal energy and sound, so the total stays the same.

11. Correct this statement: "A 500 g ball dropped 2 m has $E_p = 500 \times 10 \times 2 = 10\,000$ J."
    Mass must be in kilograms: 500 g = 0.5 kg, so $E_p = 0.5 \times 10 \times 2 = 10$ J.

12. Correct this statement: "Doubling the speed doubles the kinetic energy."
    Speed is squared in $E_k = \frac{1}{2}mv^2$, so doubling the speed makes the kinetic energy four times as big.