

Work done, power and mechanical energy

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Worksheet answers

Each answer shows the equation, the substitution and the final result with its unit in bold. Use the working to find where a mistake started, not only to check the number. Where g is needed, the value 9.8 N/kg is used.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS3-1

Problem 1 Formulas and units

1. $W = F \times d$.
2. $P = E \div t$.
3. $1\text{ W} = 1\text{ J/s}$.
4. $KE = \frac{1}{2} m v^2$ and $GPE = m g h$.

Problem 2 Pushing a handcart

1. $W = F \times d$.
2. $W = 220 \times 35 = \mathbf{7700\text{ J}}$.

Problem 3 Tractor and plough

1. $d = W \div F$.
2. $d = 4800 \div 600 = \mathbf{8.0\text{ m}}$.

Problem 4 A motor at work

1. $P = W \div t = 7500 \div 30 = \mathbf{250\text{ W}}$.
2. $\mathbf{250\text{ J}}$ every second.

Problem 5 Unit conversions

1. $2.5 \times 1000 = \mathbf{2500\text{ W}}$.
2. $450 \times 1000 = \mathbf{450\text{ 000 J}}$.
3. $3 \times 60 = \mathbf{180\text{ s}}$.
4. $E = P \times t = 1500 \times 240 = \mathbf{360\text{ 000 J}}$ (360 kJ).

Problem 6 Is work being done?

1. **No work.** The upward force is at right angles to the horizontal movement.
2. **No work.** The barbell does not move, so the distance is zero.
3. **Yes.** The lifting force acts in the direction of the movement, so the container gains

potential energy.

Problem 7 Climbing the stairs

1. $W = m g h = 52 \times 9.8 \times 3.6 = \mathbf{1830 \text{ J}}$ (1834.6 J).
2. $P = W \div t = 1834.6 \div 8.0 = \mathbf{229 \text{ W}}$.

Problem 8 Cricket ball

1. $KE = \frac{1}{2} \times 0.16 \times 30^2 = \frac{1}{2} \times 0.16 \times 900 = \mathbf{72 \text{ J}}$.

Problem 9 Water on the roof

1. $GPE = 800 \times 9.8 \times 12 = \mathbf{94\ 080 \text{ J}}$.
2. $\mathbf{94.1 \text{ kJ}}$.

Problem 10 Variable force

1. Rectangle: $40 \times 2 = \mathbf{80 \text{ J}}$.
2. Triangle: $\frac{1}{2} \times 4 \times 40 = \mathbf{80 \text{ J}}$.
3. $80 + 80 = \mathbf{160 \text{ J}}$.

Problem 11 Doubling the speed

1. At 10 m/s: $\frac{1}{2} \times 1200 \times 100 = \mathbf{60\ 000 \text{ J}}$. At 20 m/s: $\frac{1}{2} \times 1200 \times 400 = \mathbf{240\ 000 \text{ J}}$.
2. $240\ 000 \div 60\ 000 = \mathbf{4}$.

Problem 12 Crane power

1. $W = 500 \times 9.8 \times 18 = \mathbf{88\ 200 \text{ J}}$.
2. $P = 88\ 200 \div 25 = 3528 \text{ W} = \mathbf{3.5 \text{ kW}}$.

Problem 13 Speed from energy

1. $v^2 = 2 \times KE \div m$.
2. $v^2 = 2 \times 20 \div 0.40 = 100$, so $v = \mathbf{10 \text{ m/s}}$.

Problem 14 Cement on a scaffold

1. $h = GPE \div (m g)$.
2. $h = 147 \div (2.5 \times 9.8) = 147 \div 24.5 = \mathbf{6.0 \text{ m}}$.

Problem 15 Cyclist braking

1. $18 \div 3.6 = \mathbf{5.0 \text{ m/s}}$.

2. $KE = \frac{1}{2} \times 84 \times 5.0^2 = \mathbf{1050\ J}$.
3. Work by brakes = KE, so $F = 1050 \div 10 = \mathbf{105\ N}$.

Problem 16 Stopping a truck

1. $KE = \frac{1}{2} \times 8000 \times 12^2 = \mathbf{576\ 000\ J}$.
2. $d = KE \div F = 576\ 000 \div 24\ 000 = \mathbf{24\ m}$.
3. $KE = \frac{1}{2} \times 8000 \times 24^2 = \mathbf{2\ 304\ 000\ J}$; $d = 2\ 304\ 000 \div 24\ 000 = \mathbf{96\ m}$.
4. Doubling the speed gives 4 × the kinetic energy. The same braking force must do 4 × the work, so the distance is 4 × larger.

Problem 17 Roller coaster

1. $GPE = 400 \times 9.8 \times 25 = \mathbf{98\ 000\ J}$.
2. $GPE\ at\ B = 400 \times 9.8 \times 5.0 = 19\ 600\ J$, so $KE = 98\ 000 - 19\ 600 = \mathbf{78\ 400\ J}$. $v^2 = 2 \times 78\ 400 \div 400 = 392$, so $v = \mathbf{19.8\ m/s}$.
3. At C all 98 000 J is kinetic: $v^2 = 2 \times 98\ 000 \div 400 = 490$, so $v = \mathbf{22\ m/s}$.
4. The energies double, but the speeds do **not change**, because the mass cancels in $\frac{1}{2} m v^2 = m g h$.

Problem 18 Farm pump

1. $W = 1200 \times 9.8 \times 9.0 = \mathbf{105\ 840\ J}$.
2. $P = 105\ 840 \div 60 = \mathbf{1764\ W}$ (about 1.8 kW).
3. $18\ 000 \div 1200 = \mathbf{15\ minutes}$.

Problem 19 Power and speed

1. $P = W \div t = F d \div t$, and $d \div t = v$, so $\mathbf{P = F v}$.
2. $P = 25 \times 8.0 = \mathbf{200\ W}$.
3. $W = P t = 200 \times 600 = \mathbf{120\ 000\ J}$.
4. $P = 100 \times 16 = \mathbf{1600\ W}$, which is **8 times** more: twice the speed and four times the force.

Problem 20 Stair-climbing comparison

1. A: $45 \times 9.8 \times 4.0 = \mathbf{1764\ J}$; B: $60 \times 9.8 \times 4.0 = \mathbf{2352\ J}$; C: $50 \times 9.8 \times 4.0 = \mathbf{1960\ J}$.
2. A: $1764 \div 6.0 = \mathbf{294\ W}$; B: $2352 \div 10 = \mathbf{235\ W}$; C: $1960 \div 5.5 = \mathbf{356\ W}$.
3. Most work: **B**. Greatest power: **C**.