

Work done, energy conservation and power

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab answers

The answers use the sample results in the table, so your own values will differ slightly. Check the method and the units, and notice how large the percentage uncertainty from the stopwatch is for short lifts.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB A.3

Question 1 Useful energy

Useful energy = $m g h = 0.050 \times 9.81 \times 0.80 = 0.392 \text{ J}$. The hanger is lifted with the load, so its mass must be included in m for the work done against gravity.

$E_{\text{useful}} = 0.39 \text{ J}$.

Question 2 Input energy

$E = V I t = 3.0 \times 0.36 \times 6.0 = 6.48 \text{ J}$. Power is $V I$ (J/s), so multiplying by the time in seconds gives joules.

$E_{\text{in}} = 6.48 \text{ J}$.

Question 3 Efficiency values

Efficiency = $1.962 \div 10.32 \times 100 \% = 19.0 \%$. The efficiency rises with the load, from about 10 % to about 19 %, because the fixed losses are shared over more useful work.

19.0 %.

Question 4 Graph

Plot input energy on the x-axis and useful energy on the y-axis, with a line of best fit through the origin. The gradient is useful $\div$ input, so it is the efficiency as a fraction. The points here fit a gradient of about 0.17.

gradient = efficiency.

Question 5 Where the energy goes

Thermal energy in the motor coils (resistance heating) and in the leads, and friction in the bearings and the spool. A little goes as sound.

mostly thermal energy.

Question 6 Uncertainty in time

Percentage uncertainty = $0.2 \div 4.1 \times 100 \% = 4.9 \%$. The input energy $V I t$ is proportional

to t , so it has at least a 4.9 % uncertainty (about 0.19 J), which is large for the smallest load.
 ± 4.9 %.

Question 7 Improvement

Time with a light gate or video slow motion to reduce reaction-time error. Read the current at several moments or use a data logger, and repeat each run three times to average. Keep the string vertical to avoid sideways friction.

use a logger and repeat runs.

Question 8 Conclusion

The motor is inefficient, between 10 % and 19 % in this range, and the efficiency rises with load. It can never reach 100 % because some input energy always becomes thermal energy in the surroundings.

efficiency below 100 %.