inkPhysics

ANSWER BOOK

Work, energy and power

Mechanics · Year 12

AQA 3.4.1.7 · CIE 5.1.1, 5.1.3, 5.1.4, 5.1.5, 5.1.6, 5.1.7
OCR A 3.3.1(a), 3.3.1(b), 3.3.1(e), 3.3.3(a), 3.3.3(b), 3.3.3(c)

19 questions · 54 marks

NAVY EDITION

SECTION A · Warm-up

A1 $W = Fs = 20 \times 3.0$ (1)
$W = 60$ J (1) [2]

A2 Power is the rate of doing work, or of transferring energy: P = work done / time taken (1). Unit: the watt, W, equal to one joule per second (1). [2]

A3 Kinetic energy = $\frac{1}{2}mv^2$ (1); change in gravitational potential energy = $mg\Delta h$ (1). [2]

A4 The force is vertical and the displacement horizontal, so the angle between them is 90° (1). $W = Fs \cos 90° = 0$: the force does no work on the bag. (1) [2]

A5 $P = 2500$ W and $t = 180$ s (1). $E = Pt = 2500 \times 180 = 4.5 \times 10^5$ J. (1) [2]

A6 The work done by the force. (1) [1]

SECTION B · Standard

B1 $W = Fs \cos\theta$ (1)
$W = 50 \times 4.0 \times \cos 30°$ (1)
$W = 173.2$ J (1) [3]

B2 (a) $KE = \frac{1}{2} \times 2.0 \times 6.0^2$ (1)
KE = 36 J (1)
(b) Work done against the force removes this energy: $s = KE/F = 36/12$ (1)
$s = 3.0$ m (1) [4]

B3 $P = mg\Delta h/t$ (1)
$P = (20 \times 9.81 \times 5.0)/4.0$ (1)
$P = 245$ W (1) [3]

B4 Efficiency = useful output / input = 600/800 (1)
Efficiency = 0.75, or 75% (1) [2]

B5 Work done = area under the force-extension graph (1) = $\frac{1}{2} \times 12 \times 0.080$ (1) = 0.48 J. (1) [3]

B6 Energy transferred = kinetic energy gained = $\frac{1}{2} \times 62 \times 9.0^2 = 2511$ J (1). $P = E/t = 2511/3.5$ (1) = 717 W (about 720 W). (1) [3]

B7 Height gained per second = 15/20 = 0.75 m (1). Extra power = mg × height gained per second = 900 × 9.81 × 0.75 (1) = 6.6 kW. (1) [3]

SECTION C · Stretch

C1 $P = Fv$ (1)
$F = P/v = 40000/25$ (1)
$F = 1600$ N (1) [3]

C2 Height gained = 4.0 sin 30° = 2.0 m (1) [5]
(a) $\Delta GPE = mg\Delta h = 10 \times 9.81 \times 2.0$ (1)
$\Delta GPE = 196.2$ J (1)
(b) $W_{friction} = 15 \times 4.0 = 60$ J (1)
(c) Total work = 256.2 J over 4.0 m, so $F = 256.2/4.0 = 64.0$ N (1)

C3 Some input energy is always transferred to unwanted forms (1), mainly heat from friction and air resistance, and sound (1). This energy is dissipated to the surroundings, so the useful output is always less than the input (1). [3]

C4 Useful output power = $mg\Delta h/t = 120 \times 9.81 \times 15/60$ (1) = 294 W (1). Efficiency = 294/500 = 0.59 (59%) (1). This is below 65%, so the pump does not meet the claim. (1) [4]

C5 Work done = area under the force-displacement graph (1): 6.0 × 2.0 + ½ × 6.0 × 2.0 = 12 + 6.0 = 18 J (1). $\frac{1}{2}mv^2 = 18$ J (1), so $v = \sqrt{(2 \times 18/0.50)} = 8.5$ m s^{-1}. (1) [4]

C6 Sensible estimates, e.g. mass 60 kg and a height gain of 3.0 m in about 3 s (1). $P = mg\Delta h/t = 60 \times 9.81 \times 3.0/3.0$ (1) ≈ 590 W, i.e. a few hundred watts. (1) [3]