InkPhysics

ANSWER BOOK

Conservation of energy

Mechanics · Year 12

AQA 3.4.1.8 · CIE 5.1.2, 5.2.1, 5.2.2, 5.2.3, 5.2.4
OCR A 3.3.1(c), 3.3.1(d), 3.3.2(a), 3.3.2(b), 3.3.2(c)

19 questions · 61 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Energy cannot be created or destroyed, only transferred from one form to another (1); the total energy of a closed system stays constant (1). [2]

A2 Gravitational potential energy is transferred to kinetic energy (1) as the ball speeds up on the way down (1). [2]

A3 $KE = ½mv^2 = ½ \times 4.0 \times 5.0^2$ (1) [2]
$KE = 50$ J (1)

A4 Gravitational potential energy is transferred to kinetic energy as the bob falls to the lowest point, where the kinetic energy is greatest (1); the kinetic energy is then transferred back to gravitational potential energy as the bob rises to the other side. (1) [2]

A5 The kinetic energy increases by a factor of 4 (1), because $KE = ½mv^2$, so it is proportional to the square of the speed and $2^2 = 4$. (1) [2]

A6 Resistive forces (air resistance) must be negligible, so no work is done against resistance. (1) [1]

SECTION B · Standard

B1 $mgh = ½mv^2$ (1) [3]
$v = \sqrt{(2gh)} = \sqrt{(2 \times 9.81 \times 1.8)}$ (1)
$v = 5.94$ m s^{-1} (1)

B2 (a) $GPE = mgh = 0.20 \times 9.81 \times 2.5$ (1) [4]
$GPE = 4.9$ J (1)
(b) All of this becomes kinetic energy (1)
$v = \sqrt{(2gh)} = 7.00$ m s^{-1} (1)

B3 $½mv^2 = mgh$ (1) [3]
$h = v^2/2g = 6.0^2/(2 \times 9.81)$ (1)
$h = 1.83$ m (1)

B4 Height drop = $4.0 \sin 30° = 2.0$ m (1) [4]
GPE released = $mgh = 5.0 \times 9.81 \times 2.0 = 98.1$ J (1)
Work against friction = $10 \times 4.0 = 40$ J (1)
KE at bottom = $98.1 - 40 = 58.1$ J, so $v = \sqrt{(2 \times KE/m)} = 4.82$ m s^{-1} (1)

B5 With no friction, $mg\Delta h = \frac{1}{2}mv^2$ (1). The mass cancels, giving $v = \sqrt{2g\Delta h}$ (1), which depends only on the height drop, and that is the same for both. (1) [3]

B6 KE = $\frac{1}{2} \times 85 \times 12^2 = 6120$ J (1). All of it is transferred by the work done against the braking force: Fd = KE (1), so $d = 6120/340 = 18$ m. (1) [3]

B7 (a) $\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + mg\Delta h$, so $v^2 = u^2 + 2g\Delta h$ (1) $= 8.0^2 + 2 \times 9.81 \times 12 = 299\ \text{m}^2\ \text{s}^{-2}$ (1); $v = 17.3\ \text{m s}^{-1}$ (1). (b) Energy is a scalar: the kinetic energy gained equals $mg\Delta h$ whatever the direction of the throw, so the final speed is fixed by the height drop alone. (1) [4]

SECTION C · Stretch

C1 Height fallen = 25 - 10 = 15 m (1) [4]
$\frac{1}{2}mv^2 = mg\Delta h$ (1)
$v = \sqrt{2g \times 15}$ (1)
$v = 17.16\ \text{m s}^{-1}$ (1)

C2 (a) Energy $\propto$ height (1) [4]
Fraction retained = 1.5/2.0 = 0.75, that is 75% (1)
(b) $v = \sqrt{2g \times 1.5}$ (1)
$v = 5.42\ \text{m s}^{-1}$ (1)

C3 The total energy is conserved (1), but useful energy is progressively transferred to dissipated forms such as heat and sound that are spread out and hard to recover (1). 'Wasted' energy means energy transferred to a less useful form, not energy lost (1). [3]

C4 GPE given up = $mg\Delta h = 68 \times 9.81 \times 3.2 = 2135$ J (1). KE at the bottom = $\frac{1}{2} \times 68 \times 6.0^2 = 1224$ J (1). Energy transferred to the surroundings by resistive forces = 2135 - 1224 = 911 J (1), which is 911/2135 = 43% of the input (1). Nearly half the energy is dissipated, so the ramp is far from frictionless and her claim is wrong. (1) [5]

C5 Initial GPE = $mg\Delta h = 0.15 \times 9.81 \times 0.080 = 0.118$ J (1). After 20 swings GPE = $0.15 \times 9.81 \times 0.030 = 0.044$ J (1). Energy dissipated = 0.118 - 0.044 = 0.074 J (1). Average per swing = $0.074/20 = 3.7 \times 10^{-3}$ J. (1) [4]

C6 The motor does work on the car, transferring energy to its gravitational potential store (1). On each descent gravitational potential energy is transferred to kinetic energy, and on each climb kinetic energy is transferred back to gravitational potential energy (1). Throughout the ride, friction and air resistance transfer some energy to internal energy of the track, wheels and air (1). The total of the car's kinetic and potential energy therefore falls steadily, so the car cannot regain its previous height and each hill must be lower than the one before (1). The brakes transfer the remaining kinetic energy to internal energy (heating) (1). At every stage the total energy, including the dissipated energy, is conserved. (1) [6]