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QUESTION WORKBOOK

Torque, angular momentum and rotational power

Engineering physics · Year 13

AQA 3.11.1

17 questions · 51 marks

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SECTION A · Warm-up

A1 State what is meant by the torque of a force about an axis, and give its unit. [2]

A2 Write the equation linking the net torque on a rotating body to its angular acceleration, and define each symbol. [2]

A3 State the principle of conservation of angular momentum. [2]

A4 Explain why an ice skater spinning with her arms outstretched speeds up when she pulls her arms in. [2]

A5 Explain how a heavy flywheel mounted on the crankshaft of a piston engine smooths out the fluctuations in torque from the power strokes. [2]

A6 Give the unit of angular momentum. [1]

SECTION B · Standard

B1 Calculate the torque produced by a force of 250 N applied tangentially at the rim of a wheel of diameter 0.60 m. [2]

B2 A flywheel of moment of inertia 8.0 kg m^2 is acted on by a constant net torque of 20 N m, starting from rest. Calculate its angular acceleration and its angular velocity after 15 s. [3]

B3 An engine develops an output power of 45 kW at 2400 revolutions per minute. Calculate the torque at the output shaft. [3]

B4 A disc of moment of inertia 0.75 kg m^2 spins at 24 rad s^{-1}. A brake applies a steady friction torque of 3.0 N m. Calculate the time taken for the disc to stop. [3]

B5 A skater spinning at 1.5 revolutions per second has a moment of inertia of 5.6 kg m^2. She pulls her arms in, reducing it to 2.0 kg m^2. Calculate her new rate of spin and the factor by which her kinetic energy changes. [3]

B6 A motor applies a constant torque of 12 N m to a shaft, turning it through 500 rad in 25 s. Calculate the work done and the average power delivered. [3]

B7 A drum of moment of inertia 4.0 kg m^2 is driven by a torque of 30 N m and opposed by a friction torque of 6.0 N m. Starting from rest, calculate its angular acceleration and the number of revolutions it makes in the first 10 s. [4]

SECTION C · Stretch

C1 A disc of moment of inertia 1.8 kg m^2 spinning at 120 rad s^{-1} is lowered onto a stationary disc of moment of inertia 1.2 kg m^2 mounted on the same axis. Friction between them brings the pair to a common angular velocity, the friction torque between the faces being 9.0 N m. Calculate the common angular velocity, the kinetic energy before and after, the energy lost, and the time the coupling takes. [6]

C2 A turbine rotor of moment of inertia 220 kg m^2 is run up from rest to 3000 revolutions per minute by a constant torque of 1100 N m. Calculate the time taken and the angle turned through, and show that the work done by the torque equals the rotor's final kinetic energy. [5]

C3 A spinning skater pulls her arms inward and her rate of spin rises. Explain why her angular momentum is unchanged while her kinetic energy increases, and state where the extra energy comes from. [4]

C4 A wheel of moment of inertia 0.40 kg m^2 spinning at 30 rad s^{-1} is brought to rest in 2.5 s by a brake pad pressed against its rim at a radius of 0.25 m. Calculate the friction force at the rim and the heat generated at the pad. [4]