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QUESTION WORKBOOK

Rotational motion and moment of inertia

Engineering physics · Year 13

AQA 3.11.1

17 questions · 51 marks

PRINT EDITION

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SECTION A · Warm-up

A1 State what is meant by the angular velocity of a rotating body, and give its SI unit. [2]

A2 Calculate the angular velocity, in rad s^{-1}, of a shaft turning at 2400 revolutions per minute. [2]

A3 State what the moment of inertia of a body measures, and the two properties of the body that fix its value. [2]

A4 Explain why a hoop has a larger moment of inertia than a uniform disc of the same mass and the same radius, about the same central axis. [2]

A5 Name the rotational quantity that corresponds to each of the following linear quantities: displacement, velocity, acceleration, mass. [2]

A6 Write the equation for the kinetic energy of a body of moment of inertia I rotating with angular velocity ω. [1]

SECTION B · Standard

B1 A grinding wheel accelerates uniformly from rest to 900 revolutions per minute in 6.0 s. Calculate its angular acceleration. [3]

B2 A turntable has a moment of inertia of 0.045 kg m^2 and rotates at 45 revolutions per minute. Calculate its rotational kinetic energy. [3]

B3 Two 0.60 kg masses are fixed to the ends of a light rod of length 0.80 m, which rotates about an axis through the rod's centre, perpendicular to it. Calculate the moment of inertia of the arrangement, and its value when each mass is moved in to 0.10 m from the axis. [3]

B4 A flywheel slows uniformly from 120 rad s^{-1} to rest in 250 revolutions. Calculate the magnitude of its angular deceleration. [3]

B5 A wheel of diameter 0.90 m turns at 12 rad s^{-1} with an angular acceleration of 3.0 rad s^{-2}. Calculate the speed of a point on the rim and its acceleration along its circular path. [3]

B6 A flywheel is a uniform disc of mass 25 kg and radius 0.30 m, for which $I = \frac{1}{2}mr^2$. Calculate the energy it stores when spun at 2000 revolutions per minute. [3]

B7 A disc starts from rest and accelerates uniformly at 4.0 rad s^{-2} for 8.0 s. Calculate the angle it turns through and the number of revolutions it makes. [3]

SECTION C · Stretch

C1 Explain why an engineer designing a flywheel energy store gains far more by doubling its angular velocity than by doubling its mass, and explain why the mass that is used is placed at the rim rather than near the axis. [4]

C2 A tram recovers braking energy in a flywheel, a uniform disc of mass 180 kg and radius 0.50 m for which $I = \frac{1}{2}mr^2$. The flywheel is charged to 3600 revolutions per minute and is regarded as discharged when it has slowed to 1800 revolutions per minute. Calculate the moment of inertia, the energy stored at each speed, the usable energy, and the time for which that usable energy could supply 40 kW.

[6]

C3 Two flywheels each have a mass of 60 kg and a radius of 0.40 m and are spun at 150 rad s^{-1}. One is a uniform disc, for which $I = \frac{1}{2}mr^2$; the other is a rim-loaded ring, for which $I = mr^2$. Calculate the energy stored by each and state which is the better design for an energy store. [4]

C4 A wheel accelerates uniformly from 8.0 rad s^{-1} to 20 rad s^{-1} while turning through 42 rad, and its kinetic energy rises by 1680 J during this change. Determine the angular acceleration, the time taken and the moment of inertia of the wheel. [5]