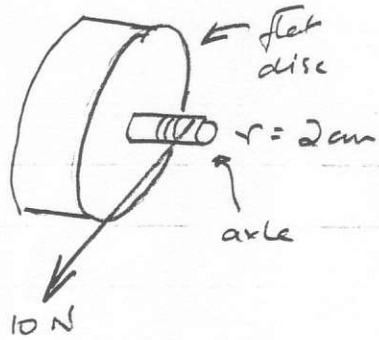
Rotation — and Flywheels

A - Physics

This exercise will give you practice in the Physics of Rotation, and more....

$M = 8\,kg$ $R = 12\,cm$



1 Treat the flywheel as a flat disc, and calculate it's Moment of Inertia, using the formula $I = \frac{1}{2}MR^2$ (kgm^2) (2)

2. With a 10N force on the axle, the flywheel, starting from rest, does 1 revolution in 2.0 sec.

Calculate... (a) the torque (2)

(b) the angular acceleration (2)

(c) the moment of inertia from this measurement. (2)

d) Are the 2 values of I the same? Have you any comment on the 2 values? (3)

3. A torque is applied that keeps the flywheel rotating with a steady angular velocity. — it does 3 revolutions in 4.1 sec.

a) Calculate the angular velocity (2)

The torque is removed and the flywheel comes to rest in 13.2 sec.

Calculate ... b) the angular acceleration (3)

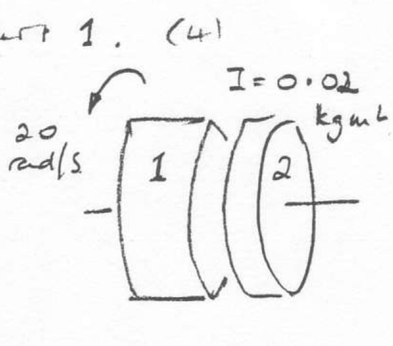
c) the frictional torque (2)

d) Calculate the rotational KE and use this to calculate... (2)

e) the angular distance turned before the flywheel stops (2)

4. Use the frictional torque to calculate an accurate value for I, and compare it with the value you got in part 1. (4)

5. A second flywheel is pushed against the first one, so they stick and rotate together. Use the idea of conserved momentum to calculate the combined angular velocity. (4)



Total.../30

3/4

4/4

3/=

2/a

1/~

MW

01.00

Rotation + flywheels — Answers — A Physics

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1. $I = \sum m r^2 = 0.0576\ \text{kg m}^2$ → into memory. (2

in m!

2. a) Torque $T = Fr = 10 \times (2 \times 10^{-2}) = 0.2\ \text{Nm}$ (2

m!

b) use (linear) $s = ut + \frac{1}{2}at^2$ (circular) $\theta = \underbrace{\omega_0 t}_{=0} + \frac{1}{2}\alpha t^2$

so $\alpha = 2\theta / t^2 = 2 \times 2\pi^{(\text{rad})} / 2.0^2 = 4\pi / 4.0 = 3.14\ \text{rad/s}^2$ (2

$= \pi$ coincidence!

c) from this $T = I\alpha \rightarrow I = T/\alpha = 0.2/3.14 = 0.064\ \text{kg m}^2$ (2

d) The 2 values of I are NOT the same – they are significantly different. why? – the value calculated in 2. is affected by friction – so the flywheel seems more "massive" – bigger moment of inertia (3 $\boxed{9}$

3. a) steady $\omega = \theta / t = 3 \times 2\pi / 4.1 = 4.6\ \text{rad/s}$ (2

slowing down

b) angular decel. $\alpha =$ change in $\omega / t = -4.6 / 13.2 = -0.35\ \text{rad/s}^2$ (2

c) $T_{friction} = I\alpha = 0.0576 \times 0.35 = 0.02\ \text{Nm}$ (2

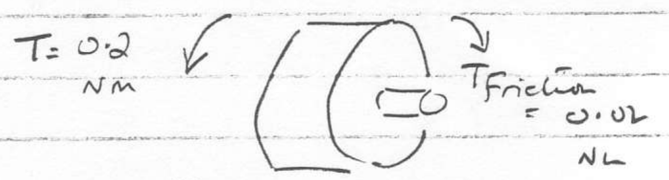
use value from (1)

d) $KE = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 0.0576 \times 4.6^2 = 0.61\ \text{J}$ (2

e) $KE \downarrow$ = work done against friction $= \theta_{turned} \times T_F$

so $\theta_{turned} = 0.61 / 0.02 = 30.5\ \text{rad}$ to come to rest (2

4. Accurate value for I



$T_{resultant} = T - T_f = 0.18\ \text{Nm}$

α still $= 3.14\ \text{rad/s}^2$

so $I = T_{res} / \alpha = 0.18 / 3.14 = 0.0573\ \text{kg m}^2$

This is v. close to the value in part 1. (4

5. momentum p_{system} = constant

$p_1 + \underbrace{p_2}_{=0} = p_{1+2}$

$(\frac{1}{2} \times 0.0576 \times 20^2) + 0 = \frac{1}{2}(0.0576 + 0.02) \times \omega^2$

$11.52 + 0 = 0.0388\,\omega^2 \Longrightarrow \omega = 17.2\ \text{rad/s}$

TW 01.00