CfE Advanced Higher Physics

Rotational Motion & Astrophysics Past Paper Homework

2. Angular Motion

1. (*a*) A turntable consists of a uniform disc of radius 0.15 m and mass 0.60 kg.

   (i) Calculate the moment of inertia of the turntable about the axis of rotation shown. 3

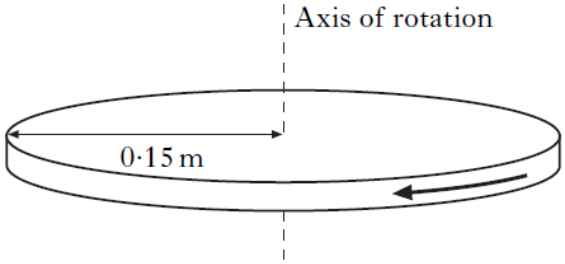


Figure 1

   (ii) The turntable accelerates uniformly from rest until it rotates at 45 revolutions per minute. The time taken for the acceleration is 1.5 s.

   (A) Show that the angular velocity after 1.5 s is 4.7 rad s^{-1}. 2

   (B) Calculate the angular acceleration of the turntable. 3

   (iii) When the turntable is rotating at 45 revolutions per minute, its motor is disengaged. The turntable continues to rotate freely with negligible friction. 3

   A small mass of 0.20 kg is dropped onto the turntable at a distance of 0.10m from the centre, as shown in Figure 2. The mass remains in this position on the turntable due to friction, and the turntable and mass rotate together.

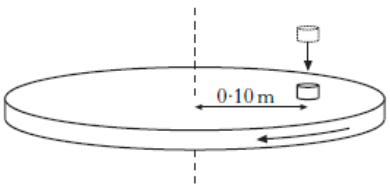


Figure 2

   Calculate the new angular velocity of the turntable and mass. 2

(13)

2. A child's toy consists of a model aircraft attached to a light cord. The aircraft is swung in a vertical circle **at constant speed** as shown in Figure 1.

X is the highest point and Y the lowest point in the circle.

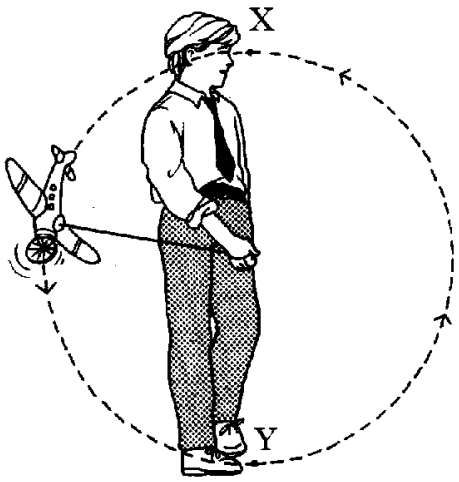


Figure 1

(*a*) The time taken for the aircraft to complete 20 revolutions is measured five times.

The mass of the aircraft and the radius of the circle are also measured. The following data is obtained.

Time for 20 revolutions: 10·05 s; 9·88 s; 10·30 s; 9·80 s; 9·97 s.
Radius of circle = 0·500 ± 0·002 m.
Mass of aircraft = 0·200 ± 0·008 kg.

(i) (A) Calculate the average period of revolution of the aircraft. **6**

(B) Assuming that the scale reading uncertainty and the calibration uncertainty of the timer are negligible, calculate the absolute uncertainty in the period. **3**

(ii) Show that the centripetal force acting on the aircraft is 15·8 N. **4**

(iii) Calculate the absolute uncertainty in this value for the centripetal force. Express your answer in the form

$$F = (15{\cdot}8 \pm \quad\quad) \text{ N}.$$

3

(iv) Draw labelled diagrams to show the forces acting on the aircraft:

(A) at position X; **2**

(B) at position Y. **2**

(v) Calculate the minimum tension in the cord. **3**

(23)

3 A compact disc (CD) stores information on the surface as shown in Figure 1.

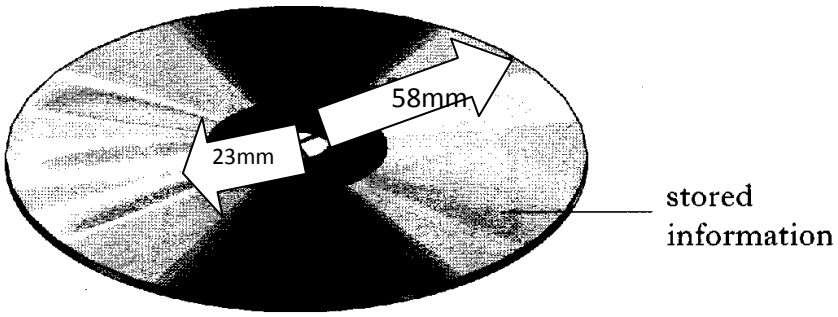


Figure 1

The information is retrieved by an optical reader which moves outwards as the CD rotates, as shown in Figure 2.

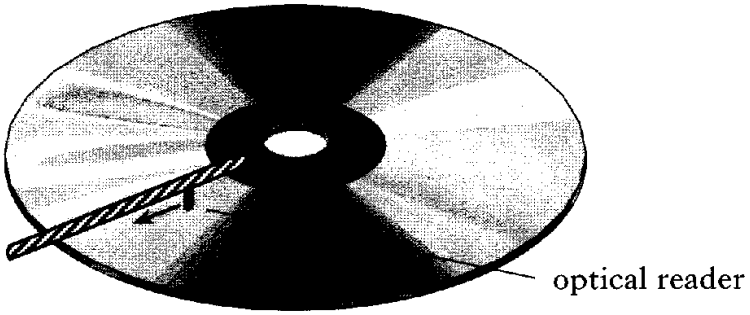


Figure 2

The part of the CD below the reader must always have a tangential speed of $1{\cdot}30\,\text{m}\,\text{s}^{-1}$.

(*a*) The reader starts at a radius of 23·0 mm from the centre of the CD. Calculate the angular velocity of the CD at the start. **3**

(*b*) Show that the CD rotates at $22{\cdot}4\,\text{rad}\,\text{s}^{-1}$ when the reader reaches the outer edge of the disc. **2**

(*c*) Explain why the angular velocity of the CD decreases as the CD plays. **2**

(*d*) The CD makes a total of $2{\cdot}80 \times 10^4$ revolutions from start to finish.

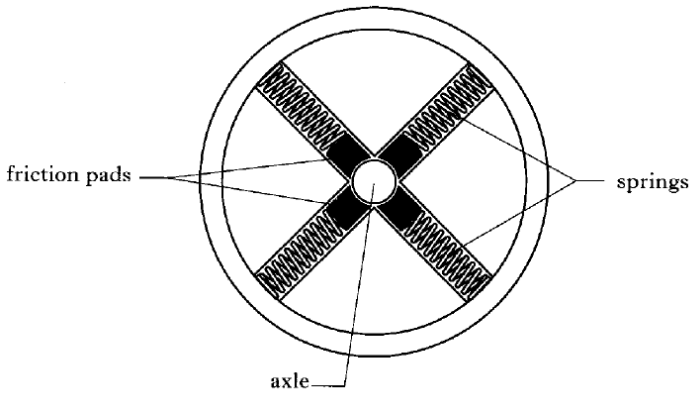
(i) Show that the total angular displacement of the CD is $1{\cdot}76 \times 10^5$ radians. **1**

(ii) Calculate the average angular acceleration of the CD as the disc is played from start to finish. **3**

(iii) Calculate the total playing time of the CD. **3**

(14)

4. One type of yo-yo has four friction pads inside each disc. Each friction pad is held in place by a spring which exerts a force of 5.00N. At low angular velocities the friction pads grip the axle as shown below.

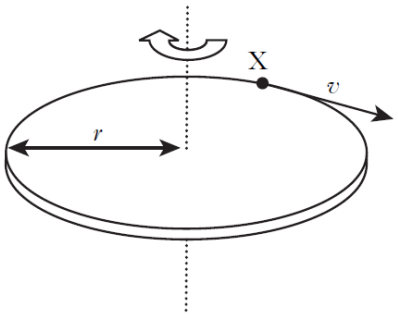


At higher angular velocities the pads move away from the axle and compress the springs. This releases the axle and allows the discs to spin freely.

(a) Explain why the friction pads move away from the axle. 1

(b) Each friction pad can be considered as a point mass of 12.0 g at a radius of 10.0mm from the centre of the axle.
Calculate the minimum angular velocity at which the axle is released from the friction pads. **(4)** 3

5. A turntable, radius *r*, rotates with a constant angular velocity ω about an axis of rotation. Point X on the circumference of the turntable is moving with a tangential speed *v*, as shown in Figure 1A.



(*a*) Derive the relationship: 3

$$v = rw.$$

(b) Data recorded for the turntable is shown below.

Angle of rotation	(3·1 ± 0·1) rad
Time taken for angle of rotation	(4·5 ± 0·1) s
Radius of disk	(0·148 ± 0·001) m

(i) Calculate the tangential speed *v*. 3

(ii) Calculate the percentage uncertainty in this value of *v*. 3

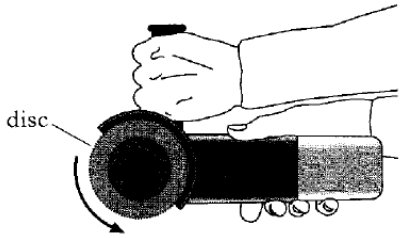
(iii) As the disk rotates, *v* remains constant.

(A) Explain why point X is accelerating. 1

(B) State the direction of this acceleration. 1

(11)

6. A grinder is used for cutting paving slabs.
The grinder has a motor and a disc with an abrasive edge as shown below.



The motor is switched on and the disc reaches a maximum angular velocity of 600 revolutions per minute. The motor is switched off and the disc slows uniformly to rest in 30s.

(a) Calculate the maximum angular velocity of the disc in $rads^{-1}$. 2

(b) Calculate the angular acceleration of the disc as it slows. 3

(c) How many revolutions does the disc make during this time? 5

(d) The moment of inertia of the disc is 2.16×10^{-3} kg $m^{2.}$ 2

Calculate the torque acting on the disc as it slows. **(12)**

Total Marks 77