Homework 2 – Angular Motion

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

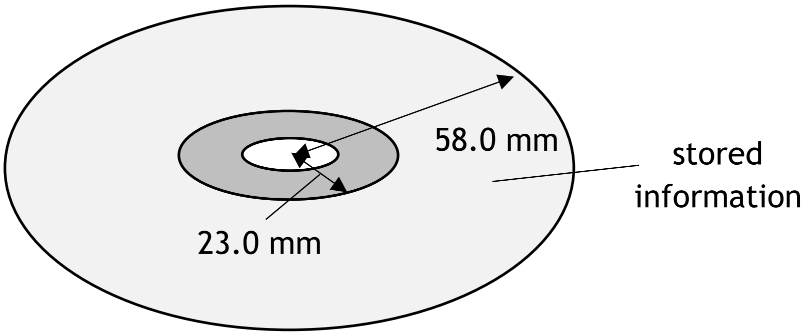


Figure 1

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

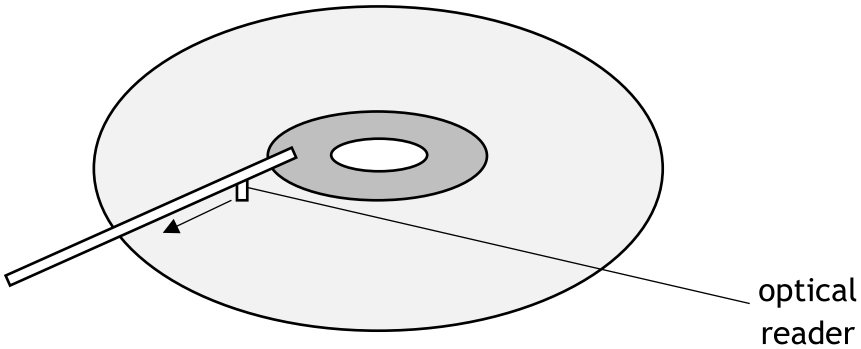


Figure 2

The part of the CD below the reader must always have a tangential velocity of $1{\cdot}30 \text{ ms}^{-1}$.

(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.

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

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

(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.

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

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

2. An anemometer is an instrument to measure wind speed and is shown in Figure 3A.

Figure 3A

The anemometer is tested in a wind tunnel.
The calibration graph of its angular velocity, in revolutions per minute, against wind speed, in ms^{-1}, is shown in figure 3B.

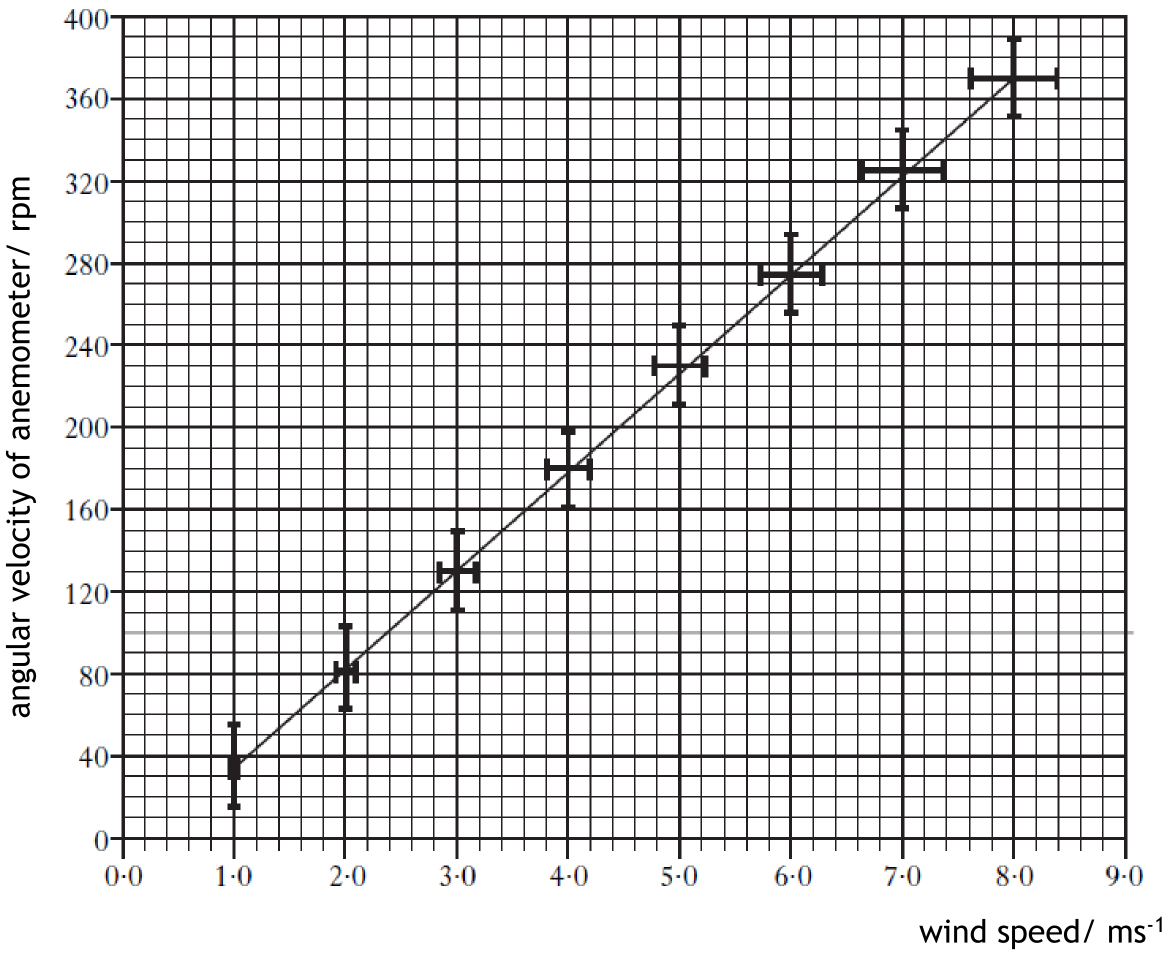


Figure 3B

The calibration graph is found not to go through the origin.

The equation for the line is $y = 48x - 12$.

(a) During one test, there is a constant wind speed of 5·8 ms^{-1}.
Show that the angular velocity of the anemometer at this wind speed is 28 rad s^{-1}.

(b) In a **second** test, the wind speed is reduced from 5·8 ms^{-1} to 1·6 ms^{-1} in a time of 8·0 s.
Calculate the angular acceleration of the anemometer.

3. A child's toy consists of a model aircraft attached to a light cord. The aircraft is swung in a vertical circle **at a constant speed** as shown in figure 4.

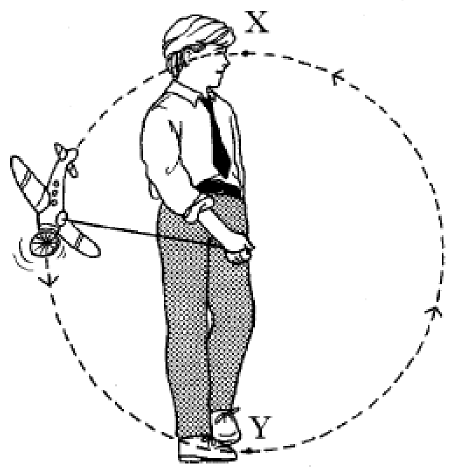


Figure 4

(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 $\pm$ 0·002 m
Mass of aircraft = 0·200 $\pm$ 0·008 kg

(i) Calculate the average period of revolution of the aircraft.
(ii) Assuming that the scale reading uncertainty and the calibration uncertainty of the timer are negligible, calculate the absolute uncertainty in the period.

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

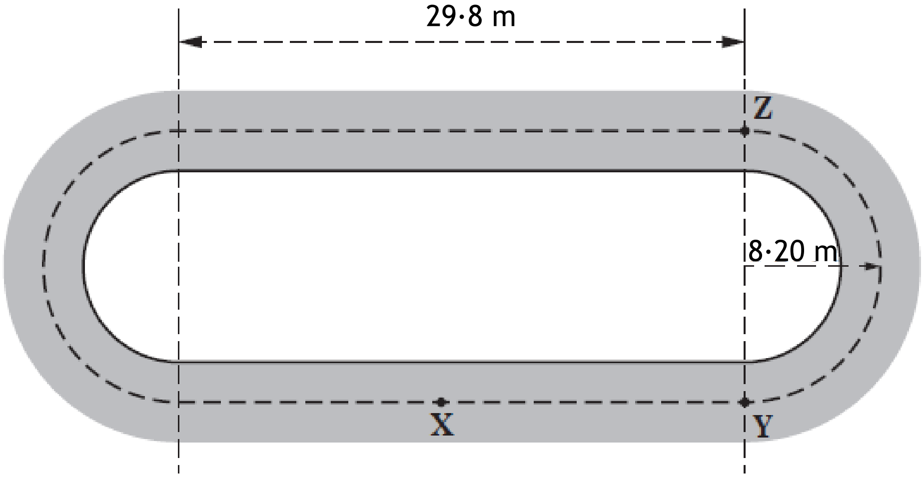
(c) Calculate the absolute uncertainty in this value for the centripetal force.
Express your answer in the form:

$$F = (15 \cdot 8 \pm \quad\quad) \, N$$

(d) Draw labelled diagrams to show the forces acting on the aircraft:
(i) at position X;
(ii) at position Y.

(e) Calculate the minimum tension in the cord.

4. The path taken by a short track speed skater is shown in Figure 5.
The path consists of two straights, each of length 29·8 m, and two semicircles each of radius 8·20 m.



Starting at point **X**, halfway along the straight, the skater accelerates uniformly from rest. She reaches a speed of 9·64 ms^{-1} at point **Y**, the end of the straight.

(a) Calculate the acceleration of the skater.

(b) The skater exits the curve at point **Z** with a speed of 10·9 ms^{-1}.
Calculate the average **angular** acceleration of the skater between **Y** and **Z.**