AP PHYSICS C: MECHANICS • EXERCISE SHEET

5.2 Connecting Linear and Rotational Motion

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

Objective

Build the skills to answer exam questions on **connecting linear and rotational motion**.

You must be able to:

- relate linear and angular speed: $v = \omega r$
- relate linear and angular acceleration: $a = \alpha r$
- explain that points farther from the axis move faster
- apply these to wheels, gears, and pulleys

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

Speed from angular speed

A point at radius r on a body spinning at ω moves at

$$v = \omega r.$$

The rim of a wheel of radius 0.3 m spinning at 10 rad s^{-1} moves at $v = 10 \times 0.3 = 3$ m s^{-1}.

Acceleration link

Likewise the tangential acceleration is

$$a = \alpha r.$$

Farther out is faster

For the same ω, a bigger r gives a bigger v. The edge of a disc outruns points near the centre.

2 Practice

Now apply the methods above.

2.1 A wheel of radius 0.5 m spins at 8 rad s^{-1}. Find the rim speed. [2]

2.2 State how the speed of a point on a spinning disc depends on its distance from the axis. [1]

2.3 A point at $r = 2$ m has angular acceleration 3 rad s^{-2}. Find its tangential acceleration. [2]

2.4 A rim moves at 6 m s^{-1} on a wheel of radius 0.2 m. Find the angular velocity. [2]

3 Exam-style questions

3.1 The relationship between rim speed and angular speed is [1]

- **A** $v = \omega / r$
- **B** $v = \omega r$
- **C** $v = r / \omega$
- **D** $v = \omega r^2$

3.2 Two points on a spinning disc: A is near the centre, B is at the rim. Compared with A, point B moves [1]

- **A** slower
- **B** faster
- **C** at the same speed
- **D** in the opposite direction

3.3 A bicycle wheel of radius 0.35 m rolls so its rim moves at 7 m s^{-1}.

(a) Find its angular velocity. [2]

(b) State the speed of the point where it touches the ground. [1]

3.4 A grinding wheel of radius 0.1 m has angular acceleration 20 rad s^{-2}.

(a) Find the tangential acceleration of a point on the rim. [2]

(b) State whether a point halfway to the centre has more or less tangential acceleration. [1]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **5.2 Connecting Linear and Rotational Motion** lesson on the **Learn** page;
- read the **Torque and Rotational Dynamics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 $v = \omega r = 8 \times 0.5 = 4$ m s^{-1}.

2.2 It is proportional to the distance from the axis (farther is faster).

2.3 $a = \alpha r = 3 \times 2 = 6$ m s^{-2}.

2.4 $\omega = v/r = 6/0.2 = 30$ rad s^{-1}.

3.1 B —$v = \omega r$.

3.2 B —the rim (larger r) moves faster.

3.3 (a) $\omega = v/r = 7/0.35 = 20$ rad s^{-1}. (b) Zero —the contact point is instantaneously at rest.

3.4 (a) $a = \alpha r = 20 \times 0.1 = 2$ m s^{-2}. (b) Less (smaller r).