Unit 1 · Rotational Dynamics and Oscillatory Motion

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

1 Key words [4]

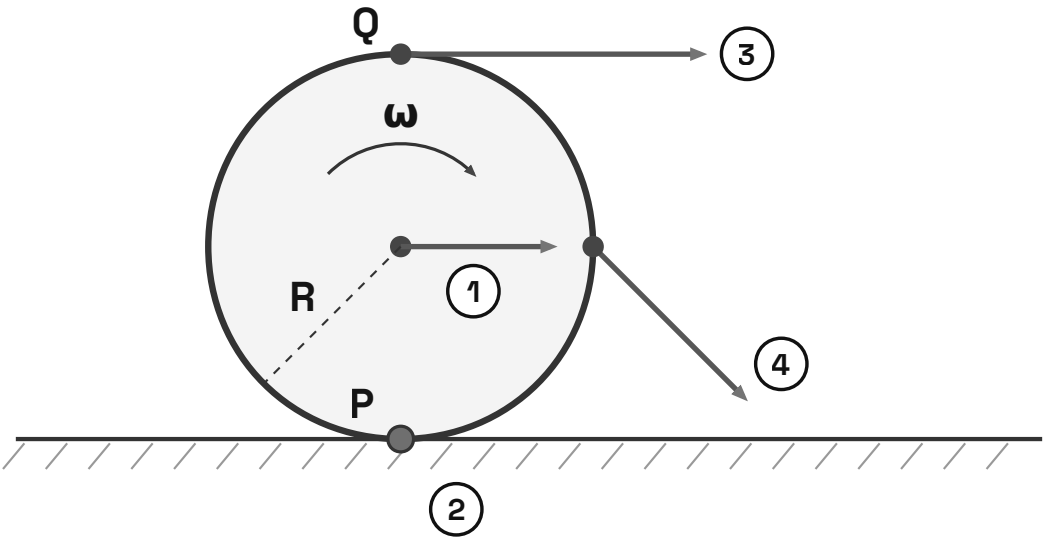
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

angular momentum	**conservation of angular momentum**	**inertial mass**	**kg m^2**	**kg m^2/s**
moment of inertia	**pure rolling**	**radius of gyration**	**rigid body**	**torque**

A body in which the distance between any two particles never changes is a _____. Its resistance to any change in its turning is its _____, measured in _____. The distance from the axis at which the whole mass could be placed with the same moment of inertia is the _____. What makes a body turn is the _____ of a force, the force times the perpendicular distance from the axis to its line of action. The product $I\omega$ is the body's _____, and it stays constant when no external torque acts: the principle of _____. A wheel whose lowest point is at rest on the road is in _____.

2 Label the diagram [2]

The diagram shows a wheel rolling without slipping. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ **2.** _____

3. _____ **4.** _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. The SI unit of angular momentum is: [1]

a. kg m^2 **b.** kg m^2/s

c. N m **d.** kg m/s

ii. The moment of inertia of a thin uniform rod about an axis through one end, perpendicular to it, compared with that about a parallel axis through its center, is: [1]

a. the same **b.** twice as large

c. four times as large **d.** half as large

iii. A thin ring of mass 0.4 kg rolls without slipping on a level floor at 2 m/s. Its total kinetic energy is: [1]

a. 0.8 J **b.** 1.6 J

c. 2.4 J **d.** 3.2 J

iv. A steady torque of 6 N m acts on a wheel of moment of inertia 1.5 kg m^2. Its angular acceleration is: [1]

a. 0.25 rad/s^2 **b.** 1.5 rad/s^2

c. 4 rad/s^2 **d.** 9 rad/s^2

v. A planet moves faster along its orbit when it is nearer the Sun because: [1]

a. the Sun's pull gives it a large torque there

b. the Sun's pull gives no torque about the Sun, so mvr stays constant

c. its moment of inertia is larger there

d. its kinetic energy stays constant

4 Short answers [7]

Write short answers to the following questions.

a. A ring and a solid disc of the same mass and radius roll from rest down the same slope. Why does the ring reach the bottom later? [2]

b. Why does the radius of gyration of a body not change if the mass of every one of its particles is doubled? [2]

c. Four small balls, each of mass 0.5 kg, are fixed on a light rod at 0.1 m, 0.2 m, 0.3 m and 0.4 m from an axis perpendicular to the rod. Find the moment of inertia of the system about the axis, and its radius of gyration. **[3]**

5 Long answer **[4]**

Write a long answer to the following question.

Derive an expression for the moment of inertia of a thin uniform rod of mass M and length l about an axis through one end, perpendicular to its length. Hence find its radius of gyration about that axis.

6 Numerical problems **[8]**

Solve the following problems. Show your working. Take $g = 9.8\ m/s^2$.

a. A solid sphere rolls without slipping from rest down a slope, through a height of 1.4 m. Find i. its speed at the bottom, ii. the fraction of its kinetic energy that is rotational, and iii. its acceleration if the slope is at 30° to the horizontal. (For a solid sphere, $K^2/R^2 = 2/5$.) **[4]**

Answer:

b. A potter's wheel is a solid disc of mass 12 kg and radius 0.3 m. A steady torque brings it from rest to 2 revolutions per second in 4 s. Find i. its moment of inertia, ii. the torque, and iii. the work done by the torque. Check iii. with the wheel's kinetic energy. **[4]**

Answer: _____

7 Think **[3]**

Two cylinders look the same from outside and have the same mass and radius, but one is a solid cylinder and the other a thin-walled tube closed with very light lids. How could you tell which is which without cutting them open? Explain why your test works.

8 Activity: Spin faster (not marked)

Sit on a chair that turns freely, holding a heavy book in each hand with your arms stretched out. A partner turns you and lets go. Count the turns you make in 5 s. Do it again with the books pulled in to your chest. Keep your feet off the floor, and stop if you feel dizzy.

	Arms	Turns in 5 s	Turns per second
First spin	stretched out		
Second spin	pulled in		

When did you turn faster? Use $I_1\omega_1 = I_2\omega_2$ to explain.