

Angular motion, torque and balance

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover the content of AP Physics 1 unit 5 on angular motion and torque: converting between degrees, radians and rpm, using constant angular acceleration equations, finding torques about an axis and applying the conditions for static equilibrium.

Start with the conversions and single-step torque problems, then move to graphs, balanced rules and beams. The last five problems follow the free-response style with derivations, an experiment design and written explanations.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 5

Problem 1 Angle conversions (easy)

Convert each angle.

1. 90° to radians, leaving π in the answer.
2. 2.5 revolutions to radians.
3. $3\pi \div 2$ rad to degrees.

Problem 2 Potter's wheel speed (easy)

A potter in Kumasi spins her wheel at 45 rpm.

1. Convert 45 rpm to rad/s.
2. Calculate the angle turned in 10 s, in radians and in revolutions.

Problem 3 Motorbike tyre (easy)

A motorbike tyre of radius 0.32 m turns at a steady 40 rad/s.

1. Calculate the speed of the bike along the road.
2. Calculate the distance covered in 5.0 s.

Problem 4 Pushing a door (easy)

A door is pushed at right angles to its surface with a 30 N force.

1. Calculate the torque about the hinge when the push is 0.80 m from the hinge.
2. Calculate the torque for the same push 0.20 m from the hinge.
3. Explain why door handles are placed far from the hinge.

Problem 5 Signs of torque (easy)

A wheel of radius 0.50 m has three forces, each at right angles to the radius at the rim: 10 N

anticlockwise, 6.0 N clockwise and 2.0 N anticlockwise.

1. Calculate each torque with its sign.
2. Calculate the net torque and say which way the wheel tends to turn.

Problem 6 Record deck spin-up (easy)

A turntable speeds up from rest to $33\frac{1}{3}$ rpm in 2.0 s at constant rate.

1. Convert the final speed to rad/s.
2. Calculate the angular acceleration.

Problem 7 Seesaw in the park (medium)

In a park in Pune, Aarav (36 kg) sits 1.8 m from the pivot of a light seesaw. His cousin sits 1.2 m from the pivot on the other side and the seesaw balances.

1. Write the torque equation about the pivot.
2. Calculate the mass of the cousin.

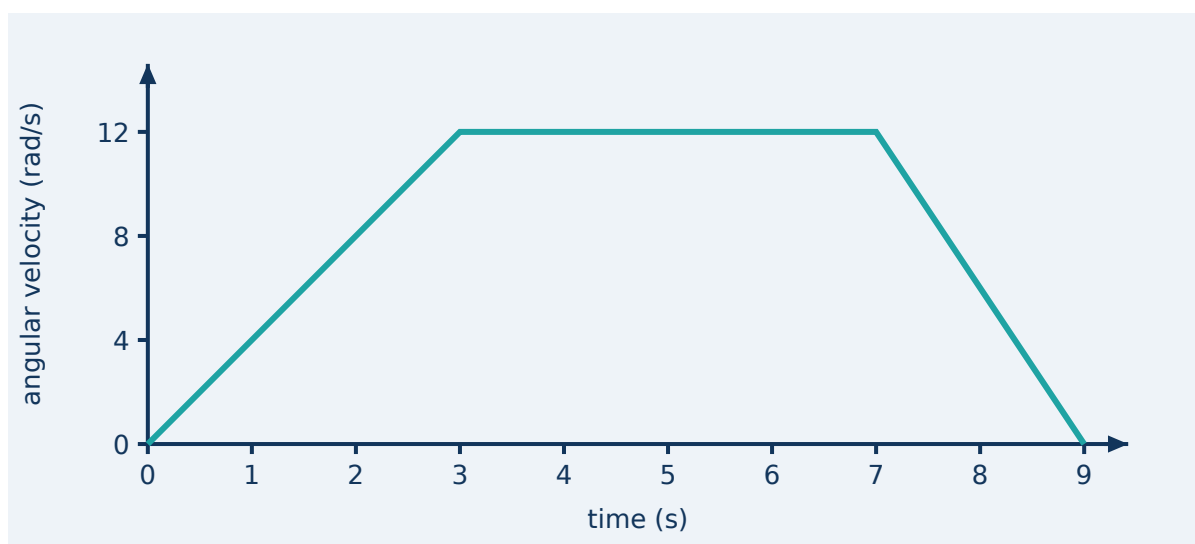
Problem 8 Bicycle wheel slowing (medium)

A bicycle wheel turns at 24 rad/s and then slows at a constant 3.0 rad/s^2 until it stops.

1. Calculate the time to stop.
2. Calculate the angle turned while stopping, in radians and revolutions.

Problem 9 Reading an angular velocity graph (medium)

The graph shows the angular velocity of a flywheel in a workshop.



Angular velocity of the flywheel.

1. Calculate the angular acceleration in each stage.
2. Calculate the total angle turned.

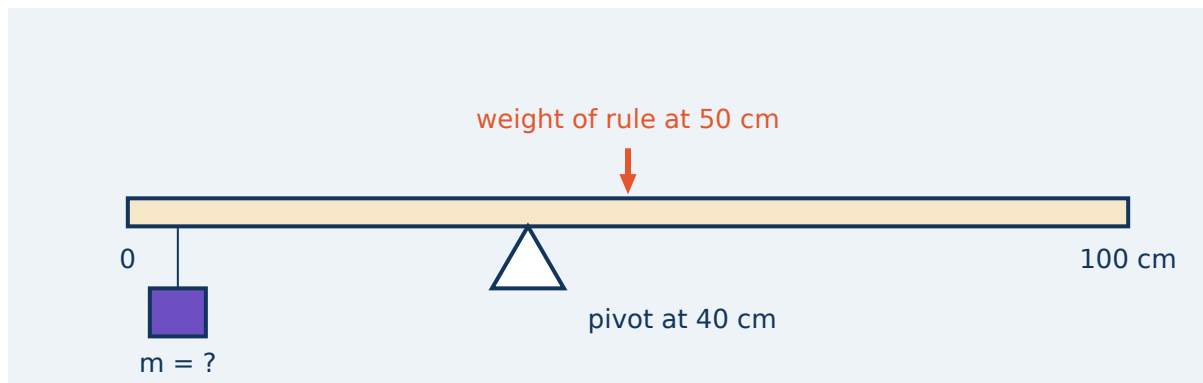
Problem 10 Spanner at an angle (medium)

A mechanic in Texas pulls with 60 N on a spanner at a point 0.30 m from the nut. The force makes 40° with the handle.

1. Calculate the torque about the nut.
2. State the angle that would give the largest torque with the same force and calculate that torque.

Problem 11 Balancing a metre rule (medium)

A uniform metre rule of mass 0.15 kg is pivoted at the 40 cm mark. A small mass is hung at the 5 cm mark so that the rule balances horizontally.



Pivot, hung mass and the weight of the rule.

1. State where the weight of the rule acts.
2. Calculate the distances from the pivot to the rule's centre and to the hung mass.
3. Calculate the hung mass.

Problem 12 Bicycle chain drive (medium)

A cyclist in Singapore pedals at 60 rpm. The front sprocket has radius 0.10 m, the rear sprocket 0.040 m and the rear wheel 0.33 m.

1. Calculate the speed of the chain.
2. Calculate the angular speed of the rear wheel in rad/s.
3. Calculate the speed of the bicycle.

Problem 13 Net torque on a light rod (medium)

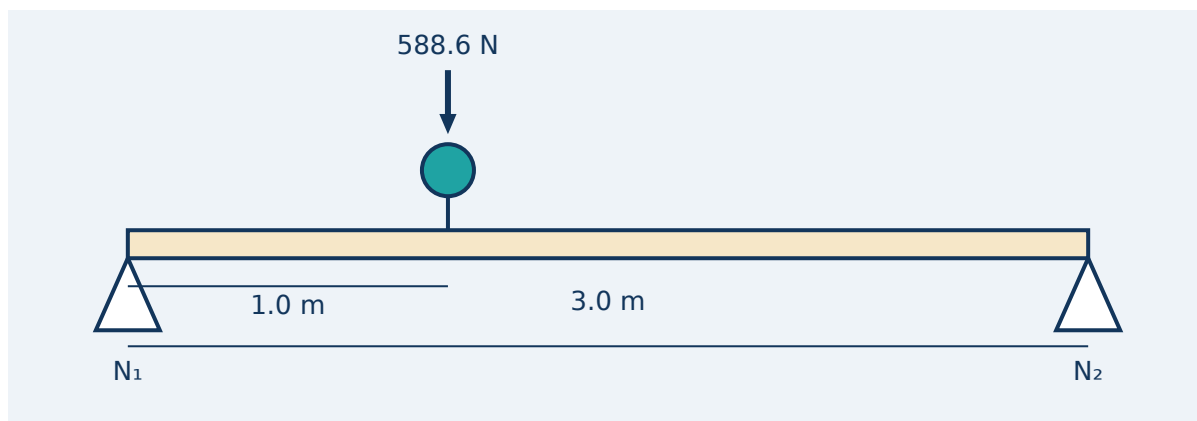
A light rod is pivoted at its left end. A 15 N force pushes up on it at 1.0 m from the pivot and a 10 N force pulls down at 0.40 m from the pivot.

1. Calculate the net torque, taking anticlockwise as positive for the upward force on the right.
2. Calculate the extra downward force at 1.1 m that would balance the rod.

Problem 14 Scaffold plank (medium)

A uniform 3.0 m plank of mass 24 kg rests on supports at its ends. A 60 kg worker stands 1.0

m from the left support.



Forces on the plank.

1. Take torques about the left support to find the force from the right support.
2. Calculate the force from the left support.

Problem 15 Long handles (medium)

A mechanic needs a torque of 40 N m to loosen a wheel nut.

1. Calculate the force needed with a spanner of effective length 0.40 m, pulling at right angles.
2. Calculate the force needed if the spanner is only 0.25 m long.
3. Explain the advantage of the longer spanner.

Problem 16 Spinning up and doubling the time (hard)

A fan starts from rest with a constant angular acceleration of 0.50 rad/s^2 . Its blade tip is 0.40 m from the axis.

1. Calculate the angle turned and the angular speed after 6.0 s.
2. Calculate the tangential acceleration and the tip speed after 6.0 s.
3. A student says that doubling the time doubles the angle turned. Test the claim with a calculation and correct it if needed.

Problem 17 Verifying torque with a rule (hard)

You have a metre rule, a knife-edge pivot, a set of slotted masses and thread. Design an experiment to test the equation $\tau = rF$ for a force perpendicular to the rule.

1. Describe the set-up and what you vary and measure.
2. Explain how you would analyse the data, naming the graph and the expected gradient.
3. State one source of error and how to reduce it.

Problem 18 Hinged beam with a cable (hard)

A uniform beam of length 3.0 m and mass 12 kg is hinged to a wall and held horizontal by a cable attached 2.0 m from the hinge. The cable makes 40° with the beam. An 8.0 kg load

hangs from the free end.

1. Take torques about the hinge to find the tension in the cable.
2. Calculate the horizontal and vertical components of the hinge force.

Problem 19 Analysing wheel data (hard)

A student records the angle turned by a wheel that starts from rest: at $t = 1.0$ s, 2.0 s, 3.0 s and 4.0 s the angles are 1.5 rad, 6.1 rad, 13.4 rad and 24.1 rad.

1. Explain why a graph of θ against t^2 should be a straight line.
2. Calculate the gradient using the first and last points and hence the angular acceleration.
3. Calculate the angular speed at 4.0 s and compare with the average speed over the first 4.0 s.

Problem 20 Equal forces, no equilibrium (hard)

Two forces of 12 N, equal in size and opposite in direction, act on the ends of a light stick 0.30 m long, each at right angles to the stick.

1. State the net force and calculate the net torque about the centre of the stick.
2. Write a short argument explaining whether the stick is in equilibrium and what changes if the torque is calculated about one end.