

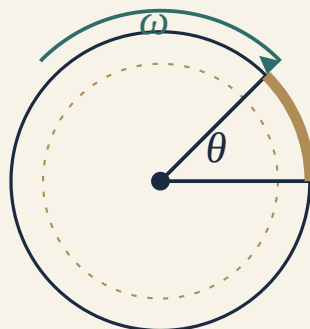
◆ DRG · PHYSICS ◆

FREE SAMPLER · ADVANCED HIGHER PHYSICS

Rotational Motion

FIVE WORKED QUESTIONS

One fully worked question from each part of the series — free to view, download and share with your class.



FREE SAMPLER

QUALIFICATIONS SCOTLAND · C857 77 · FORMERLY SQA
A DRG-PHYSICS PRODUCT · COMPILED & WRITTEN BY DR GODOY

HOW TO USE THIS SAMPLER

Try These First

Five questions, one from each booklet in the series. Cover the worked solution, attempt the question, then mark yourself line by line.

Every DrG-Physics solution is laid out the way a marker reads it: relationship, substitution, answer with unit — each mark shown by a gold dot. The teal *why* notes explain the reasoning behind each step.

MARKING CONVENTION

1 mark for the relationship, 1 for the substitution, 1 for the final answer with its unit. Use $g = 9.8 \text{ N kg}^{-1}$ from the data sheet. α is angular acceleration; a is linear.

In this sampler

RM01 · Differentiating a displacement function	5 marks
RM02 · A wheel spinning up from rest	6 marks
RM03 · A vertical circle with energy	11 marks
RM04 · Measuring a moment of inertia	9 marks
RM05 · The spinning skater	7 marks

The full series

RM01 **Kinematic Relationships** · Calculus of motion · graphs · deriving the equations

RM02 **Angular Motion** · Radians · angular equations · linking rotation to the line

RM03 **Centripetal Force** · Circular motion · vertical circles · banking and cones

RM04 **Torque & Moment of Inertia** · Rotational dynamics · $\tau = Fr$ · $\tau = I\alpha$

RM05 **Angular Momentum & Rotational Energy** · $L = I\omega$ · conservation · rolling objects

RM ★ **Rotational Motion — Complete Edition** · all five parts in one volume

© 2026 Dr Godoy (Dr G) · DrG-Physics. All rights reserved. The research, problem design, worked solutions, key words and logical process in this sampler are the author's personal intellectual work, protected under copyright law. Digital tools were used to support data research and formatting; all content was written, checked and approved by the author. Free to download and to share with students in its original, unaltered form with attribution. Any other reproduction, adaptation, resale or uploading to other platforms is forbidden without the author's written permission.

RM01 · KINEMATICS · PRACTICE

SAMPLE 1 · RM01 *Differentiating a displacement function*

5 MARKS

The displacement s of a trolley along a track is given by

$$s = 4.0t^3 - 6.0t^2 + 2.0t$$

where s is in metres and t in seconds.

- (a) Calculate the velocity of the trolley at $t = 3.0$ s. CALCULATE · 2 MARKS (2)
- (b) Calculate the acceleration of the trolley at $t = 3.0$ s. CALCULATE · 2 MARKS (2)
- (c) Determine the time at which the acceleration is zero. DETERMINE · 1 MARK (1)

WORKED SOLUTION

- (a) $v = \frac{ds}{dt} = 12t^2 - 12t + 2.0$ (1)
- WHY** Velocity is the rate of change of displacement, so differentiate term by term: $4.0t^3 \rightarrow 12t^2$, $-6.0t^2 \rightarrow -12t$, $2.0t \rightarrow 2.0$.
- $v = 12(3.0)^2 - 12(3.0) + 2.0 = 108 - 36 + 2.0$
- WHY** Substitute $t = 3.0$ s only after differentiating.
- $v = 74 \text{ m s}^{-1}$ (2)
- (b) $a = \frac{dv}{dt} = 24t - 12$ (1)
- WHY** Differentiate the velocity function again.
- $a = 24(3.0) - 12 = 60 \text{ m s}^{-2}$ (2)
- (c) $24t - 12 = 0 \Rightarrow t = 0.50 \text{ s}$ (1)
- WHY** Set the acceleration function equal to zero and solve. This is where the velocity is at a minimum.

EXAMINER'S NOTE

The mark is for the differentiated function, not for the number. A candidate who substitutes $t = 3.0$ into the displacement and divides by 3.0 has found an average, and scores nothing for (a).

DO

- ✓ Differentiate first, substitute second.
- ✓ Write the function you obtained before any numbers.

DON'T

- ✗ Divide s by t — that is an average velocity.
- ✗ Use $v = u + at$: a is not constant here.

RM02 · ANGULAR MOTION · PRACTICE

SAMPLE 2 · RM02 *A wheel spinning up from rest*

6 MARKS

A potter's wheel starts from rest and accelerates uniformly to an angular velocity of 9.0 rad s^{-1} in 6.0 s .

- (a) Calculate the angular acceleration of the wheel. (3)
 (b) Calculate the number of revolutions the wheel makes in this time. (3)

WORKED SOLUTION

- (a) $\omega = \omega_0 + \alpha t$ (1)
 WHY "From rest" gives $\omega_0 = 0$. "Uniformly" tells you α is constant, so the angular equations apply.
 $9.0 = 0 + \alpha \times 6.0$ (2)
 WHY Substitute first, then rearrange the numbers.
 $\alpha = 1.5 \text{ rad s}^{-2}$ (3)
- (b) $\theta = \omega_0 t + \frac{1}{2} \alpha t^2$ (1)
 $\theta = 0 + \frac{1}{2} \times 1.5 \times 6.0^2 = 27 \text{ rad}$ (2)
 WHY Show the square in the substitution — markers look for 6.0^2 .
 $N = \frac{27}{2\pi} = 4.3 \text{ revolutions}$ (3)
 WHY Radians to revolutions: divide by 2π .

EXAMINER'S NOTE

The final mark in (b) is for revolutions, not radians. Stopping at 27 rad answers a different question.

DO

- ✓ Write $\omega_0 = 0$ in your data.
- ✓ Divide by 2π to get revolutions.

DON'T

- ✗ Write a for α .
- ✗ Round α before using it in (b).

RM03 · CENTRIPETAL FORCE · PRACTICE

SAMPLE 3 · RM03 *A vertical circle with energy*

11 MARKS

A 1.5 kg ball on a string of length 0.90 m moves in a vertical circle. At the top of the circle its speed is 4.0 m s^{-1} . Air resistance is negligible.

- (a) Calculate the tension in the string at the top of the circle. CALCULATE · 3 MARKS (3)
- (b) Calculate the speed of the ball at the bottom of the circle. CALCULATE · 3 MARKS (3)
- (c) Calculate the tension in the string at the bottom of the circle. CALCULATE · 3 MARKS (3)
- (d) Calculate the minimum speed at the top for the ball to complete the circle. CALCULATE · 2 MARKS (2)

WORKED SOLUTION

- (a) $T + mg = \frac{mv^2}{r}$ (1)
WHY At the top, tension and weight both point to the centre, so they add to give the centripetal force.
 $T + (1.5 \times 9.8) = \frac{1.5 \times 4.0^2}{0.90}$ (2)
WHY Use $g = 9.8$ from the data sheet.
 $T = 26.7 - 14.7 \Rightarrow T = 12 \text{ N}$ (3)
- (b) $\frac{1}{2}mv_b^2 = \frac{1}{2}mv_t^2 + mgh$, with $h = 2r = 1.8 \text{ m}$ (1)
WHY Energy is conserved. The ball falls the full diameter between top and bottom.
 $v_b^2 = 4.0^2 + 2 \times 9.8 \times 1.8 = 51.28$ (2)
WHY Mass cancels from every term.
 $v_b = 7.2 \text{ m s}^{-1}$ (3)
- (c) $T - mg = \frac{mv^2}{r}$ (1)
WHY At the bottom, tension points up to the centre and weight points away from it.
 $T = \frac{1.5 \times 51.28}{0.90} + 14.7$ (2)
WHY Use the unrounded $v^2 = 51.28$ from (b).
 $T = 1.0 \times 10^2 \text{ N}$ (3)
WHY About eight times the tension at the top: strings break at the bottom.
- (d) $T = 0: mg = mv^2/r \Rightarrow v = \sqrt{gr}$ (1)
WHY At the minimum speed the string is just slack, so weight alone provides the centripetal force.
 $v = \sqrt{9.8 \times 0.90} = 3.0 \text{ m s}^{-1}$ (2)

EXAMINER'S NOTE

Energy first, then forces. The two classic slips are $h = r$ instead of $2r$, and using the top speed in the bottom equation.

DO

- ✓ Draw the forces at the top and at the bottom.
- ✓ Use $h = 2r$ between top and bottom.

DON'T

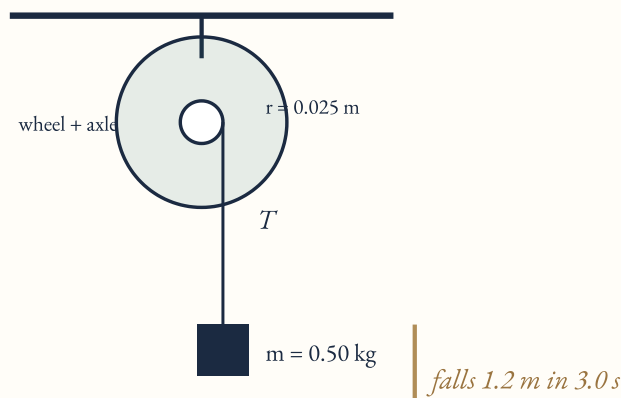
- ✗ Write $T = mv^2/r$ anywhere in a vertical circle.
- ✗ Use 9.81 — the data sheet value is 9.8.

RM04 · TORQUE & INERTIA · PRACTICE

SAMPLE 4 · RM04 *Measuring a moment of inertia*

9 MARKS

A 0.50 kg mass hangs from a light string wound round the axle of a wheel. The axle has a radius of 0.025 m. The mass is released from rest and falls 1.2 m in 3.0 s. Friction is negligible.



- (a) Show that the acceleration of the falling mass is about 0.27 m s^{-2} . (2)
 (b) Calculate the tension in the string. (3)
 (c) Calculate the moment of inertia of the wheel and axle. (4)

WORKED SOLUTION

- (a) $s = ut + \frac{1}{2}at^2 \Rightarrow 1.2 = 0 + \frac{1}{2} \times a \times 3.0^2$ (1)
 WHY The mass has constant acceleration and starts from rest.
 $a = 0.267 \text{ m s}^{-2} \approx 0.27 \text{ m s}^{-2}$ (2)
- (b) $mg - T = ma$ (1)
 WHY Newton's second law for the falling mass: weight down, tension up, resultant down.
 $T = 0.50 \times (9.8 - 0.267)$ (2)
 $T = 4.8 \text{ N}$ (3)
- (c) $\tau = Tr = 4.77 \times 0.025 = 0.119 \text{ N m}$ (1)
 WHY The tension acts tangentially at the axle radius.
 $\alpha = a/r = 0.267/0.025 = 10.7 \text{ rad s}^{-2}$ (2)
 WHY The string does not slip, so the axle surface has the same tangential acceleration as the mass.
 $I = \tau/\alpha = 0.119/10.7$ (3)
 $I = 0.011 \text{ kg m}^2$ (4)

EXAMINER'S NOTE

Using $\tau = mgr$ assumes the string tension equals the weight — only true if the mass is not accelerating. Find T first.

DO

- ✓ Find a , then T , then τ and α .
- ✓ Use $a = r\alpha$ to link the line to the wheel.

DON'T

- ✗ Use $T = mg$.
- ✗ Round a to 0.27 before using it.

RM05 · MOMENTUM & ENERGY · PRACTICE

SAMPLE 5 · RM05 *The spinning skater*

7 MARKS

An ice skater spins with her arms outstretched. Her moment of inertia is 3.2 kg m^2 and her angular velocity is 4.0 rad s^{-1} . She pulls her arms in, reducing her moment of inertia to 1.1 kg m^2 .

- (a) State the principle of conservation of angular momentum. (1)
STATE · 1 MARK
- (b) Calculate her angular velocity with her arms pulled in. (3)
CALCULATE · 3 MARKS
- (c) Show by calculation that her rotational kinetic energy increases, and explain where the extra energy comes from. (3)
SHOW + EXPLAIN · 3 MARKS

WORKED SOLUTION

- (a) In the absence of an external torque, the total angular momentum of a system remains constant. (1)
WHY The condition is part of the mark.
- (b) $I_1\omega_1 = I_2\omega_2$ (1)
WHY Friction from the ice is negligible, so there is no external torque.
- $3.2 \times 4.0 = 1.1 \times \omega_2$ (2)
 $\omega_2 = 12 \text{ rad s}^{-1}$ (3)
WHY 11.6 rad s^{-1} is also accepted.
- (c) Before: $\frac{1}{2} \times 3.2 \times 4.0^2 = 26 \text{ J}$ (1)
 After: $\frac{1}{2} \times 1.1 \times 11.6^2 = 74 \text{ J}$ (2)
WHY Use the unrounded ω_2 .
- The skater does work pulling her arms inwards (against their tendency to continue in a straight line); this work becomes extra kinetic energy. (3)

EXAMINER'S NOTE

Kinetic energy is *not* conserved here. A candidate who equates the energies in (b) gets $\omega_2 = 6.8 \text{ rad s}^{-1}$ and loses all three marks.

DO

- ✓ Include the condition in the principle.
- ✓ Use L for the calculation and E for the explanation.

DON'T

- ✗ Conserve kinetic energy.
- ✗ Say energy was “created”.

A Final Word

I *f you can write the relationship, substitute cleanly and finish with a unit — calmly, one line at a time — the marks in rotational motion are yours.*

The DrG-Physics Rotational Motion series

RM01 **Kinematic Relationships** · Calculus of motion · graphs · deriving the equations

RM02 **Angular Motion** · Radians · angular equations · linking rotation to the line

RM03 **Centripetal Force** · Circular motion · vertical circles · banking and cones

RM04 **Torque & Moment of Inertia** · Rotational dynamics · $\tau = Fr$ · $\tau = I\alpha$

RM05 **Angular Momentum & Rotational Energy** · $L = I\omega$ · conservation · rolling objects

RM ★ **Rotational Motion — Complete Edition** · all five parts in one volume

Available as STUDY and EXAM editions. Find the full catalogue at **drg-physics.com** and on TES (shop: DrG-Physics). Schools and departments: drgodoyphysics@gmail.com.

“Physics rewards the student who writes one calm sentence per line.”

— DRG-PHYSICS —

— FINIS —

A DRG-PHYSICS PRODUCT · ROTATIONAL MOTION · ADVANCED HIGHER PHYSICS

© 2026 Dr Godoy (Dr G) · DrG-Physics. All rights reserved. The research, problem design, worked solutions, key words and logical process in this sampler are the author’s personal intellectual work, protected under copyright law. Digital tools were used to support data research and formatting; all content was written, checked and approved by the author. Free to download and to share with students in its original, unaltered form with attribution. Any other reproduction, adaptation, resale or uploading to other platforms is forbidden without the author’s written permission.