**Rotational Motion Review**

**Task A:** Complete a mind map on A3 paper, adding detail from points 1), 2) & 3) below and pages 59 to 78 from your course book, by reviewing the relevant **theory** section (purple boxes).

1. **KNOW THE EQUATIONS:**



|  |  |  |  |
| --- | --- | --- | --- |
| Equation |  | Symbol’s **complete** name And SI unit | Situation where equation is most commonly used (or notes about this equation).  |
| Conversion equations | d | Distance moved around arc (m) | This set is known as “conversion equations” for Angular to Linear values. Can be used to find distance for wheel to stop (d) from radius of wheel and radians wheel spins.Can be used to find vf, vi, ωf, ωi during acceleration problems as well. |
| r | Radius of circle (m) |
| θ | Angular displacement (radians) |
|  | v | Tangential velocity (ms-1) |
| ω | Angular velocity (rad s-1) |
|  | a | Centripetal acceleration (ms-2) |
| α | Angular acceleration (rad s-2) |
|  | Δ θ | Change in angular displacement (rad) | ONLY for constant angular speed! NO acceleration! |
| Δ t | Change in time (s) |
|  | Δ ω | Change in angular velocity (rad s-1) | Definition of angular acceleration. Also one of the angular mechanics equations in “simple” form. Assumes constant angular acceleration. |
|  | ω | Angular freq (or velocity) (rad s-1) | Conversion equation since EVERY CIRCLE = 2π RADIANSIn SHM, ω = angular frequency = rate of change of angle in reference circle. |
| f | Frequency (Hz) |
|  | T | Period (s) | Can be seen as . f also known as “number of cycles per second” |
|  | EK(ROT) | Rotational Kinetic Energy (J) | can be paired with and maybe  for energy conservation (assumes no friction or energy-loss)… usually to find I |
| I | Rotational Inertia (kg m2) |
|  |  |  |  |
|  |  |  |
|  | ω f | Final Angular Velocity (rad s-1) | Angular Kinemactics Set: Assumes constant angular acceleration.In same pattern as year 12 physics linear mechanics equation set.Must know 3 values to find other 2 values.Common mistake: using  (constant speed equation) when NOT allowed (i.e. no acceleration). |
| ω i | Initial Angular Velocity(rad s-1) |
| Angular Kinematics | α | Angular Acceleration (rad s-2) |
|  | θ | Angular Displacement (rad) |
|  | t | Time (s) |
|  | τ | Torque (Nm) | Can be paired with or or  |
| I | Angular Inertia (kg m2) |
| α | Angular Acceleration (rad s-2) |
|  | F | Force (N) | Can be paired with  .  When doing angular acceleration with rope and mass: F = mg can be involved. |
| r | Radius (or distance from fulcrum to force) (m) |
|  | L | Angular Momentum (kg m2 s-1) | Used for “car driving onto turntable”, “bullet hitting spinner” and “astronauts on rope”.  |
| m | Mass (kg) |
| v | Linear (tangential) Velocity (ms-1) |
|  |  |  | Used for helicopters, ice scatters and solid spinning masses.  |

1. **Be familiar with the NCEA standard: what COULD be on the exam:**
* **Rotational motion with constant angular speed and with constant angular acceleration;**
* **torque;**
* **rotational inertia;**
* **angular momentum;**
* **rotational kinetic energy;**
* **conservation of angular momentum;**
* **conservation of energy**
1. **Know the MEANINGS of the key-words or common terms**
2. translational motion
3. rotational motion (angular motion)
4. angular displacement
5. angular velocity
6. angular acceleration
7. angular frequency
8. frequency
9. period
10. linear displacement
11. linear velocity (tangential)
12. linear acceleration (centripetal)
13. moment of inertia (rotational inertia)
14. angular momentum
15. linear momentum
16. torque
17. Law of conservation of angular momentum
18. Law of conservation of energy
19. rotational kinetic energy
20. linear kinetic energy
21. gravitational potential energy
22. radian
23. radian per second
24. radian per second squared
25. kilogram meter squared
26. kilogram meter squared per second

**TASK B: Be familiar with the COMMON DIAGRAMS and GRAPHS:**

(and know the details, labels, possible equations and *explanations* that accompany them)

EXPLAIN AND UNDERSTANDING PHYSICS DIAGRAMS MAKES FOR EXCELLENT REVISION!

Look at each diagram and calculate all possible values and describe EACH situation (eg ?1 ?2).

θ

t

Write a story that explains each graph:

θ

t

ω

t

ω

t

1

?1

?4

?2

?3

2

9.6m

22°

Calculate rotational inertia of ball

Time down ramp = 14s

3

r = 0.07m

m = 18g

4

Solid vs hollow disks

?1

?2

?3

?4

7

movable pocket

Turntable with movable masses

6

?1

?1

?3

?2

?4

5

**TASK C: Practice NCEA application based questions**

1. Angular Mechanics Revision Question Set

|  |  |
| --- | --- |
| **maxine’s motorbike** Maxine has just purchased a motorbike. After kick-starting it and putting it into first gear, Maxine eases off the clutch and takes off smoothly reaching 5.55ms-1 in 2.50s before changing to second gear. |  |
| Q1a | What is Maxine’s acceleration over this time? |
| 1b | Show that, with a rear diameter of 700mm, (3 s.f.) the back wheel undergoes an angular acceleration of 6.34 rad s-2. |
| The mass of Maxine and her bike is 150kg. (3 s.f.) |
| 1c | Calculate the unbalanced torque with which the back wheel applies this force. |
| The chain cog on the back wheel has a diameter of 200mm (3 s.f.). |
| 1d | What is the tension force, FT which the chain must exert on the cog to achieve the torque required for this acceleration. |
| Maxine’s friend, Neil is keen to demonstrate his riding skills. He revs up and lets the clutch out quickly. The front wheel lifts up and Neil falls off the back. |  |
| 1e | Explain why the front wheel came up. |

|  |  |  |
| --- | --- | --- |
| **QUESTION 2** Arabella is set the task of finding the rotational inertia (I) of a solid cylinder, experimentally. She uses an arrangement of the equipment, as shown below. The cylinder is mounted on an axle and can rotate freely about it – you can assume that there is no friction and that g=9.8 ms-2

|  |  |
| --- | --- |
| The cylinder has a radius of 0.20 m. A string is wrapped around it with mass of 2.0 kg on the end. Arabella found that when released from rest the 2.0 kg mass took 1.0 s to fall 2.0 m. She then calculated the acceleration and the final speed v of this mass. |  |

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| Calculate: |
| 2a | The acceleration, a, of the falling mass. |
| 2b | The final speed, v, of the falling mass. |
| 2c | Calculate the angular acceleration, α, of the wheel. |
| 2d | Draw a free body diagram force diagram of the 2.0 kg mass and use it to show that the tension Ft in the string is 12 N. |
| 2e | Calculate the torque being applied to the wheel. |
| 2f | Find the value of the rotational inertia I. Give the correct unit. |
| 2g | Arabella now replaces the original solid cylinder with one of the same mass and radius that is hollow and has most of its mass concentrated at the outside. She repeats the experiment. How will the value of I compare with the value for the solid cylinder. Explain your answer. |

1. Angular Momentum and Energy Question Set

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| --- | --- |
| QUESTION 3 **The Bus** A bus in Zurich, Switzerland, has a large flywheel to provide energy to the drive wheels between bus stops. At each stop, the bus connects to overhead contacts that deliver electricity to a motor that accelerates the flywheel while passengers get on and off.This bus has an advantage over regular diesel buses when it uses its brakes. Energy can be stored on the flywheel via the braking system. |  |
| The flywheel is a solid cylinder with I = 405 kg m2, and a top speed of 1500 rev min-1. The bus, including the flywheel and passengers, has a mass of 1.00 x 104 kg. |
| **(a)** | Show that the rotational kinetic energy of the flywheel at top speed is 5.00 x 106 J. |
| **(b)** | If the average power required to operate the bus is 15 kW, how long should the bus spend travelling between stops? |
| The bus stops at the top of the hill. The spare wheel gets dislodged and rolls down the hill. The radius of the wheel = 0.480m and has a mass of 67.0kg. |
| **(c)** | When the wheel has descended a vertical distance of 19.0m, it has a linear speed of 15.0ms-1. Using the principle of conservation of energy, calculate the rotational inertia of the wheel. |
| **(d)** | In answering 3c) list any assumptions you have made in determining the value of the rotational inertia |

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| **QUESTION 4 The Rotating Earth** Mass of the Earth: M = 5.97 x 1024 kgRadius of the Earth: R = 6.37 x 106 mPeriod of the Earth’s Rotation about its axis: T = 24.0 hoursThe planet Earth undergoes a variety of motions, spinning about its own axis in one day while also orbiting around the sun in one year. |
| **(a)** | Calculate the linear speed of a point on the Earth's Equator. |
| **(b)** | If people on earth are moving at the speed calculated in 2(a) then we would be travelling faster than the speed of sound. Why are we not always breaking the sound barrier making loud bangs as we do so?  |
|  **(c)** | Show that the angular velocity of the Earth about its own axis is 7.27 x 10-5 rad s-1. |
|  **(d)** | Would all people on earth be travelling at the speed calculated in 2(a)? Explain your answer |
|  **(e)** | Calculate the angular displacement of a point on the Equator after 3 hours. |
|  **(f)** | Use the formula I = 2/5 MR2 to calculate the rotational inertia of the rotating Earth. |
|  **(g)** | Calculate the angular momentum of the Earth's rotation about its axis. |
| Imagine that an asteroid with a mass of 2.00 x 1018 kg and moving at a speed of 3.00 x 106 m s-1 struck the Earth at the Equator as shown in the diagram below (the asteroid’s velocity vector is tangent to the Earth’s equator and in the same direction as the Earth’s spin). The asteroid embeds in the Earth's surface at the point of collision. |
|  |
|  **(h)** | Show that the angular momentum of the asteroid just before the collision, about the centre of the Earth, is 3.82 x 1031 kg m2 s-1 |
|  **(i)** | Calculate the new period of the Earth’s rotation after the collision with the asteroid has occurred. |
| Imagine that the Antarctic icecap were to melt and release a very large volume of water into the ocean where it would spread towards the Equator. |
|  **(j)** | Explain what would happen to the Earth’s angular velocity |
|  **(k)** | Would the length of day increase or decrease? Explain your answer. |
| **(l)** | Is the earth supplying a torque to the moon as it rotates around us. Explain your answer. |