Level I

1. **Crafting Joules**

A single bolt of lightning carries approximately 5 billion joules of energy. The battery capacity of a Tesla Model S P100D is 100kWh. Assuming 80% efficiency in power transmission, how many Teslas can Elon Musk fully charge­­­ if he harnesses a single lightning bolt?

The Tesla Gigafactory 1 in Nevada has a projected yearly capacity of 150GWh/yr. How many bolts of lightning per day are required to meet capacity?

Level II

Level III

1. **Hello Major Tom**
2. **Are you receiving?**
3. **Turn your thrusters on**

A ring-shaped space station is in orbit around Earth. It has a radius , and a mass . There are jets situated around the perimeter of the station that provide constant thrust tangential to the ring. If it begins at rest (rotationally), how long will it take for the station reach an angular velocity, , such that, at the point farthest from the center, the astronauts feel gravity . Give your answer in terms of the variables given.

Let’s begin with an equation that involves time and rotational motion. This could be any kinematic equation for rotational motion, but I chose the simplest one.

We have to find the final angular velocity of the space station and the angular acceleration due to the thrusters.

Part 1. Find the angular velocity

|  |  |  |
| --- | --- | --- |
| There’s an equation for centripetal acceleration involving angular velocity, but I don’t remember it. However, I do remember the equation with linear velocity. |  |  |
| Convert between rotational and linear velocity with . |  |  |
| If the centripetal acceleration is gravity, the equation becomes |  |  |
| Rearrange the equation to isolate . |  |  |
| Check the units to make sure the equation makes sense |  |  |

Part 2. Find rotational acceleration

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| The torque from the thrusters. is a multiplier, because we have thrusters. |  |  |
| The thrusters apply force tangential to the hoop, so and . The equation simplifies to |  |  |
| Torque is also equal to |  |  |
| Combining the two equations, we get |  |  |
| Isolate |  |  |
| The moment of inertia I of a hoop with radius r and mass m is |  |  |
| Plugging into the angular acceleration equation |  |  |
|  |  |  |

Part 3. Putting it all together

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| Now we can plug in and into |  |  |
| Simplify. |  |  |