

# Order-of-Magnitude Estimation

## Collapsing Sun (Level 3)

### The Question

If the Sun wasn't supported by internal pressure, how long would it take to completely collapse?

### Background

The Sun is stable because it is in a state of balance known as “hydrostatic equilibrium”. Pressure is created from internal nuclear reactions as the Sun fuses hydrogen into helium to create energy. This outwards pressure perfectly balances the inwards force of gravity—hence the equilibrium. If the nuclear fusion reactions in the Sun “turned off” then there would be nothing to balance the Sun’s gravitational pull on itself and the Sun would collapse. This is actually a realistic scenario. In about 5 billion years’ time the Sun will have exhausted the hydrogen in its core and will begin to contract. Though the Sun will never collapse completely, this problem yields a reasonable estimate of the collapse timescale.

This problem can be reduced to a “free fall” problem. The conditions for “free fall” are that an object falls under constant acceleration caused by the gravity due to a massive body. Constant acceleration is typically a reasonable assumption when the total amount of mass that is interior to the freely falling body does not change. Such conditions would hold in this case, as the total mass of the Sun is kept interior to the surface of the Sun as it collapses. It may also be useful to read the additional background provided in the “Falling Ball” question.

### The Solution

## Education Standards

This OoM Estimation problems meets the following standards in **bold**:  
*Next Generation Science Standards (NGSS)*:

- Physical Sciences
  - Matter & Its Interactions
  - **Motion and Stability: Forces and Interactions**
  - Energy
  - Waves and Their Applications in Technologies for Information Transfer
- Life Sciences
  - From Molecules to Organisms: Structures and Processes
  - **Ecosystems: Interactions, Energy, and Dynamics**
  - Heredity: Inheritance and Variation of Traits
  - Biological Evolution: Unity and Diversity
- Earth and Space Sciences
  - **Earth's Place in the Universe**
  - Earth's Systems
  - Earth and Human Activity
- Engineering, Technology, and Applications of Science
  - **Engineering Design**

*Common Core Standards (CSS)*:

- **Counting & Cardinality**
- **Operations & Algebraic Thinking**
- **Numbers & Operations in Base Ten**
- **Number & Operations — Fractions**
- Measurement & Data
- **Geometry**
- **Ratios & Proportional Relationships**
- The Number System
- **Expressions & Equations**
- Functions
- Statistics & Probability