

# JEE Advanced 2019 - Paper 1 - Physics 11

Senan

## Problem [ Multiple Choice Multiple Correct ]

Let us consider a system of units in which mass and angular momentum are dimensionless. If length has dimension of L, which of the following statement(s) is/are correct?

- (A) The dimension of linear momentum is  $L^{-1}$
- (B) The dimension of energy is  $L^{-2}$
- (C) The dimension of force is  $L^{-3}$
- (D) The dimension of power is  $L^{-5}$

## What to Observe:

- Mass is dimensionless.
- Angular momentum is dimensionless.
- Length has dimension of L.
- The system of units is such that some physical quantities may have different dimensional representations.

## My Approach:

### Converting SI System to New System

#### Thought

To convert any physical quantity from one system to another, we need to establish a dimensional equivalence between the two systems.

In the new system, **mass is dimensionless**. Therefore,

$$m \Rightarrow [M^0 L^0 T^0]$$

Next, consider the expression for angular momentum:

$$\text{Angular Momentum} = mvr$$

As **angular momentum is dimensionless** in the new system:

$$mvr \Rightarrow [M^0 L^0 T^0]$$

Since mass is dimensionless, it follows that:

$$vr \Rightarrow [M^0 L^0 T^0]$$

Thus, the velocity has dimensions:

$$v \Rightarrow \frac{1}{r} \Rightarrow [M^0 L^{-1} T^0]$$

In the SI system, the dimension of velocity is:

$$v_{\text{SI}} \Rightarrow [L^1 T^{-1}]$$

Equating the two expressions for velocity:

$$[L^1 T^{-1}]_{\text{SI}} = [M^0 L^{-1} T^0]_{\text{new}}$$

From this, we can isolate the time dimension:

$$[T^{-1}]_{\text{SI}} = [M^0 L^{-2} T^0]_{\text{new}} \Rightarrow [T]_{\text{SI}} = [M^0 L^2 T^0]_{\text{new}}$$

This gives the equivalence for time in the SI system in terms of the new system.

## Checking The Options

#### Thought

We have established the following equivalences:

- Mass:  $[M^1 L^0 T^0]_{\text{SI}} = [M^0 L^0 T^0]_{\text{new}}$
- Length:  $[M^0 L^1 T^0]_{\text{SI}} = [M^0 L^1 T^0]_{\text{new}}$
- Time:  $[M^0 L^0 T^1]_{\text{SI}} = [M^0 L^2 T^0]_{\text{new}}$

Now, let us determine the dimensions of various physical quantities in the SI system and convert them to the new system.

**Linear Momentum** ( $p = mv$ ):

$$[p]_{\text{SI}} = [M^1 L^1 T^{-1}]$$

Substituting each base unit:

$$\Rightarrow [M^0 L^0 T^0] \cdot [M^0 L^1 T^0] \cdot [M^0 L^2 T^0]^{-1} = [M^0 L^{-1} T^0]_{\text{new}}$$

Therefore, **Option A is incorrect.**

**Energy** ( $E = \frac{1}{2}mv^2$  or  $Fd$ ):

$$[E]_{\text{SI}} = [M^1 L^2 T^{-2}]$$

Substituting:

$$\Rightarrow [M^0 L^0 T^0] \cdot [M^0 L^1 T^0]^2 \cdot [M^0 L^2 T^0]^{-2} = [M^0 L^{-2} T^0]_{\text{new}}$$

Therefore, **Option B is correct.**

**Force** ( $F = ma$ ):

$$[F]_{\text{SI}} = [M^1 L^1 T^{-2}]$$

Substituting:

$$\Rightarrow [M^0 L^0 T^0] \cdot [M^0 L^1 T^0] \cdot [M^0 L^2 T^0]^{-2} = [M^0 L^{-3} T^0]_{\text{new}}$$

Therefore, **Option C is correct.**

**Power** ( $P = \frac{E}{t}$ ):

$$[P]_{\text{SI}} = [M^1 L^2 T^{-3}]$$

Substituting:

$$\Rightarrow [M^0 L^0 T^0] \cdot [M^0 L^1 T^0]^2 \cdot [M^0 L^2 T^0]^{-3} = [M^0 L^{-4} T^0]_{\text{new}}$$

Therefore, **Option D is incorrect.**

### Conclusion

Based on the detailed analysis and the computed expression for the physical quantity under consideration:

Options B and C are correct.

Option A and Option D is incorrect because the calculated value does not agree with the value stated in that option.

### Support the Channel:

If you found this explanation helpful and it helped you think like a JEE Advanced ranker, consider supporting the channel!

- **Subscribe** to *The Bored IITian* for more such high-quality JEE problem breakdowns.
- **Share it with 3 friends** who have **never heard of the channel**. Help them level up too!
- Drop a comment or suggestion - your feedback helps improve future content.

*Note from Senan:* The way I solve and explain problems in this PDF is simply how I personally approach and think through JEE questions. This is **not** the only way to solve them. What I'm sharing here is my mindset and thought process - use it as inspiration, not as a prescription. Develop your own flow, but always stay curious and logical!

**YouTube Channel:** [youtube.com/@bored\\_iitian](https://youtube.com/@bored_iitian)