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Test Your Knowledge of The Chemistry of Elements

1. The second most abundant element in the universe.
2. The densest element.
3. The element which forms the largest number of stable isotopes.
4. The photoconducting element used in 'xerography'
5. The most electronegative metal.
6. Two ferromagnetic metals other than iron.
7. The element of highest melting point.
8. The most abundant rare gas in air.
9. The element whose production is the largest electrochemical industry in the world.
10. The element which forms the largest number of compounds.

The answers are given on page 95.

## Suggested Reading


- **F M Miller. *Chemistry – Structure and dynamics.* McGraw–Hill. New York, 1985.**
- **N N Greenwood and A Earnshaw. *Chemistry of the elements.* Maxwell Macmillan International Edition. Pergamon Press. Oxford, 1989.**


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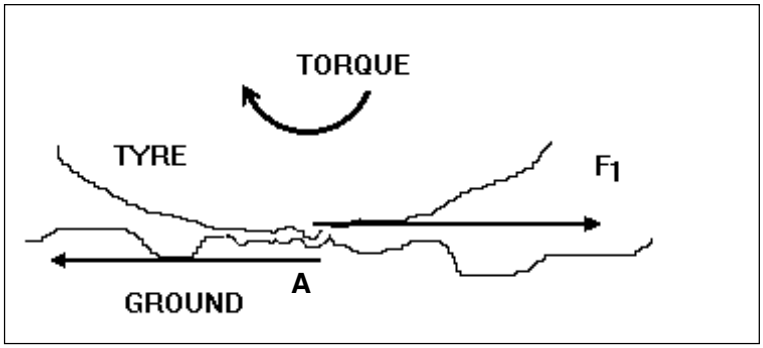
Question raised in the *Think It Over* section of *Resonance*, Vol.1, No.8

**Which Direction Does the Frictional Force Act?**
**Consider a bicycle moving from the West to East. What is the frictional force acting on each wheel, when**
**a) The cycle is being pedalled? and**
**b) When it is moving freely (without being pedalled)?**

In the August 96 issue of *Resonance*, J V Shreyas raised an innocent looking question about the forces which act on the wheels of a bicycle under various conditions. We received many responses both from students and professional scientists. We naturally cannot publish and comment on all the material which




*Contact of rear wheel with the ground. Roughness of ground and tyre exaggerated for clarity!*

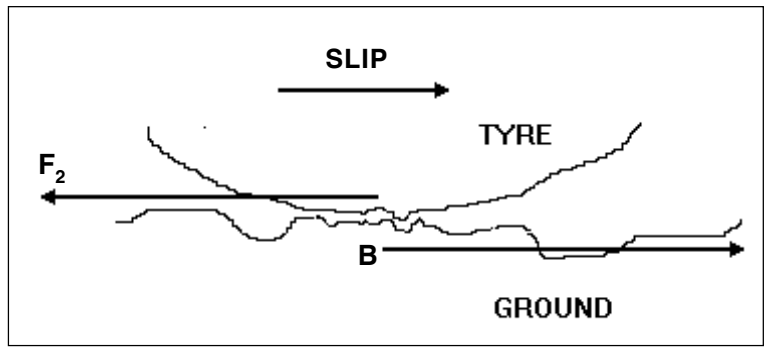
they submitted K R Shashi Kiran of Bangalore, sent us a discussion which captures the basic physics in a simple way and raises a new question as well! We give below an edited extract from his letter.

"Consider a bicycle being pedalled from west to east. When you start pedalling the bicycle the chain exerts a torque on the back wheel of the bicycle with the result that it starts spinning with its angular velocity pointing into the page.

Let us consider the microscopic view of point A, where the back wheel of the bicycle touches the ground.

As the wheel spins, the projections of the wheel push the projections of the ground backward (i.e in the western direction). According to Newton's third law of motion, the ground pushes the tyre forward. This force, the force of reaction, is the frictional force $F_1$, acting on the wheel in the *forward* direction. This frictional force pushes the centre of mass of the wheel forward. Since the centre of mass of the back wheel is set into motion, the centre of mass of the bicycle and hence that of the front wheel is also set into motion from west to east. If the front wheel has zero angular velocity to start with, (i.e. it is not spinning) there is a tendency of that wheel to slip.

Let us consider the microscopic view of the point B, where the front wheel touches the ground.




*Contact of front wheel with the ground.*

As the wheel tends to slip, the projections of the wheel push those of the ground forward. In return, the ground pushes the wheel backward. This force is nothing but the frictional force $F_2$, acting *backwards* on the wheel. "

Shashi Kiran then goes on to point out that when the rider stops pedalling, the frictional force has to act backwards on both the wheels. He then asks "the professors of *Resonance* " why the *angular* velocity of the wheels reduces. A glance at the sketches shows that the same backward frictional force would produce a torque *increasing* the angular velocity! Rather than spoil the fun that readers may have answering his query, let me just remark that only a few of the practicing physicists to whom I posed the question were able to come up with a convincing answer! The common element of their approach was to think in more detail about the region of contact.

V Raghunath from Mumbai, has given a similar discussion of the frictional forces, but also asks us to consider the question of stability – how the rider prevents the bicycle from falling down. Here, I will only offer the hint that if the handlebar of a bicycle is locked, even in a straight position, one cannot balance while riding the cycle! The freedom to turn the handlebar even by an amount so small that we don't notice it in normal riding, is vital to the stability of the bicycle. Clearly, the humble bicycle has much to offer the thinking physicist and perhaps we will meet it again on these pages.

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