NEW!! Readers Corner

Brunelleschi's Dome

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In this issue we are piloting our new "Readers' Corner". We hope it will provide an opportunity for our readers to share information about exciting science-teaching related books.

Rating: * highly recommended;**
**** recommended; *not recommended**

Our debut review is from Jim Hunt, University of Guelph, jhunt@uoguelph.ca

Brunelleschi's Dome by Ross King
Penguin Books. ISBN 0 14 20.0015 9

RATING : ***

In case you missed this incredible story in 2000 this will remind you. It is the life of Filippo Brunelleschi (1377-1446), ("Pippo" to the few friends he had) great mathematician, equally great artist, genius architect, treacherous friend, implacable enemy, plotter and inventor. In spite of the close rivalry of the renowned sculptor Lorenzo Ghiberti, Pippo won the competition that would make him the greatest architect of the renaissance and perhaps of all time. The competition was to construct the great dome on the Cathedral of Florence "Santa Maria del Fiore".

Brunelleschi contracted to construct the largest masonry dome in the world which would be exceeded in span only by the Roman Parthenon and that was concrete and didn't count. This gargantuan dome was to be 115 m from the crowning cross to the ground and have a span of 42 m. The great marvel however was that Pippo vowed that he would build it without "centering" (the timber support for domes and arches that is removed after the completion of the work); there wasn't enough timber in Italy to permit that. Construction started in 1420 and took only 16 years to build - a short time considering that the Cathedral took 170 years to complete.

King tells the story of Brunelleschi's lifelong struggle against the force of gravity and containment of thrust forces, to have a brick-and-mortar shell creep out over a vast empty space with nothing to support it but itself and his genius for design. The technical details are important to understand Pippo's triumph and King explains them clearly. The real story, however is that of the malignant genius who contracted to do the impossible and did it. The dome has not been exceeded to this day.

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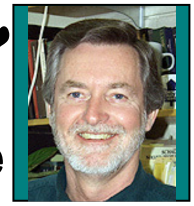
Book recommendations and short reviews will be gladly received by the column editor.

Bernoulli's Principle: Under Pressure



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In this demonstration, we utilize simple everyday household items to test Bernoulli's principle and verify the apparent counterintuitive nature of its predictions.

Bernoulli's principle, after the Swiss scientist Daniel Bernoulli (1700-1782), relates the pressure P, flow speed v, and the elevation of a fluid. The equation that expresses this principle quantitatively (assuming the fluid does not change elevation) is

$$P + \tfrac{1}{2}\rho v^2 = \text{constant},$$

where ρ is the density.

A major prediction of Bernoulli's principle emerges from this equation: where the velocity of a fluid is relatively high, the associated fluid pressure is relatively low, and vice versa.

This demonstration requires a blower (a shop vac, electric leaf-blower or air mattress pump can be used), large cork stopper with small hole (~ 0.5 cm diameter), and a metal disc (bristol board disc can be substituted) with a small nail stuck to the surface.

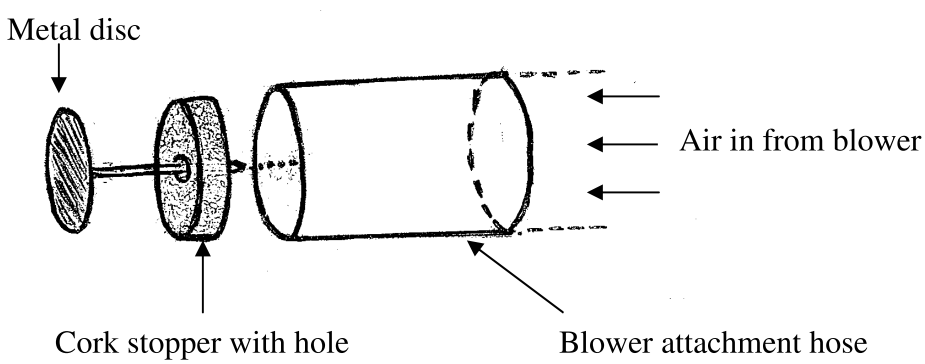

Figure 1. Equipment setup for demonstration.

Figure 1 illustrates the equipment: the cork stopper is fitted into the blower attachment hose and held in place so that air from the blower is forced through the small hole at the centre of the stopper, at high velocity. Before moving the metal disc towards the hole in the stopper, I usually ask the class to predict the outcome and also to confirm that the blower is indeed blowing air outwards and not in vacuum mode, i.e., not sucking air in. (A quick blast of air at a few students confirms this.) Most students predict that the disc would be blown away due to the high pressure generated as a result of the high velocity of air issuing from the hole in the stopper, with the logic of their prediction (based on experience) being that a rapidly moving fluid has a high pressure.

When the disc is brought close to the hole it is clear that it is attracted to, and remains suspended close to, the cork stopper (Fig. 2). This counterintuitive result is a consequence of Bernoulli's equation. Because the air speed is very high as the air moves through the narrow gap between the cork and the disc, the pressure is low. Consequently, the air pressure above the disc is less than the atmospheric air pressure beneath the disc, resulting in a net upward air-force on the disc, which balances the downward weight of the disc.

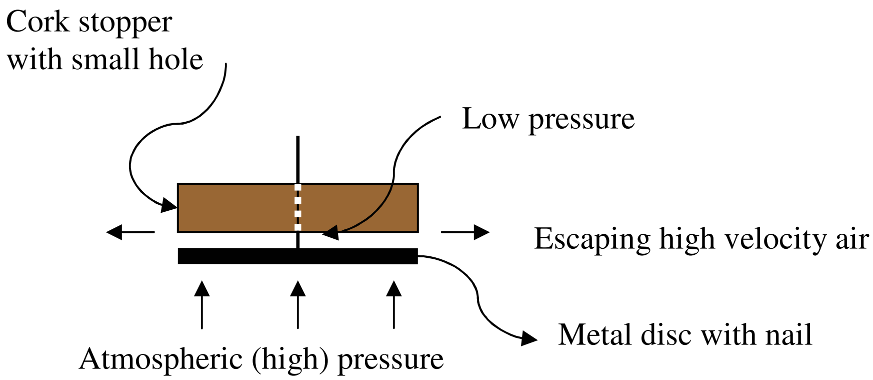

Figure 2. With the metal disc close to the cork stopper the pressure difference across the disc causes it to be attracted toward the stopper and remain suspended below the small hole through which high-velocity air is escaping. The small nail stuck to the disc surface and inserted into the hole in the stopper prevents lateral movement of the disc.

A useful explanation for students as to why their prediction — that high fluid velocities give rise to high pressure — is incorrect, and to clarify any misconceptions, is the example of a person being hit and knocked over by fast-moving water out of a fire-hose. The force that knocks you over is indeed due to fluid pressure, and you would justifiably conclude that the pressure was high. However the pressure is not high until you slow down the water by getting in its way. The rapidly moving water in the jet is approximately at atmospheric pressure before it hits you, but as you stop the water, its pressure increases dramatically.

Bernoulli's principle explains many other common phenomena such as the (perfume) spray atomizer, the dynamic lift experienced by aircraft wings and the motion of "curve balls" in baseball.

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Submissions describing demonstrations will be gladly received by the column editor.

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Timely Topics Sourced by: Donald Messenger

Timely Topics is a list of topical articles of interest to Members. Examples are:

- Lasers to create mini sun in hunt for clean energy
- U of O scientist wins $1M Herzberg prize
- NASA searches for next Earth
- Scientists closer to making invisibility cloak a reality
- Dedicated physics teacher makes house call in another country
- Antimatter in the movies

High School Physics

Turning a Motorcycle: The Curious Case of the Counter-steer

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There you are, riding your motorcycle down the street in a straight line at a constant speed of 50 km/h while mouthing the lyrics of Born to Be Wild and imagining yourself as Peter Fonda in Easy Rider. As you approach the next corner, you want to initiate a sharp left turn.
How do you do it?

a) steer the handlebars to the left
b) shift your weight to lean the motorcycle to the left
c) both a) and b) are required
d) either a) or b) will initiate the left turn
e) steer the handlebars to the right

My current Iron Horse: 1982 Kawasaki KZ250LTD

Even seasoned veterans of the two-wheeled vehicle will more often than not pick the incorrect answer. The correct answer is e).

Just before you fire off an abusive email questioning where I might have purchased my undergraduate degree, let me hasten to add that I rode a number of different motorcycles for many years before this simple proposition was presented to me. How did I come to accept that it was true?

Consider the operation of a motorcycle. The front wheel acts like a gyroscope. The faster you go, the more stable it becomes. Below about 20 km/h, its angular momentum is low enough that you can steer the motorcycle to the left by turning the handlebars to the left. You might even be able to shift your weight enough to make that work, although you will be unlikely to make a really sharp turn unless you are riding a very light motorcycle.

Go faster, and at some point the unexpected happens. Shifting your weight has little effect on the direction of travel. Hard steering to the left results in a surprisingly violent lean to the right. The only way you can initiate a safe turn to the left is to momentarily countersteer, i.e., apply pressure to turn the handlebars to the right. The result? A lean to the left, making as sharp a turn as you desire.

Since this is a newsletter for physics teachers, I'll leave it to you to apply the right hand rule to determine the direction of precession of the gyroscopic front wheel of the motorcycle as you turn the handlebars left, and then, right, applying a torque to the axis of rotation through the front forks. Any elementary college or university text can help you, if it's been a while since you considered the physics of rotating bodies.

Of course, pencil, paper, and the right hand rule are not as satisfying as a real experiment. If you don't have access to a motorcycle, you can get almost the same effect from a bicycle. Being much lighter, you can turn a bicycle to some extent by weight shifting even at higher bicycling speeds. However, try riding along in a straight line, as fast as you can. Then, gently apply pressure to turn the handlebars to the right. The result may surprise you.