September 2000
Regulars

Letters

Adhesion and Cohesion

Hello, I'm doing a research project at Purdue University and one part of the project requires a mathematical analysis of fluid interaction with a surface. Specifically, I need to find an expression for the distance from a surface that the fluid will start to rise (or decline) due to the effects of adhesion and cohesion. An example of this is the meniscus in a cylinder of fluid. I'd imagine this expression would be a function of the properties of the fluid and the contact surface. Thanks.

Jeremy Davis

I'm afraid this level of detail is a bit beyond the remit of a publication like Plus (which is aimed at school level rather than University), but I can give you some pointers on the web. The rise/decline can be expressed as a function of the contact angle (which depends on the fluid and the surface). Have a look at:

http://www.wl.k12.in.us/depts/science/earth_science/frameworks/ch11/meniscus.html

http://www.britannica.com/bcom/eb/article/9/0,5716,119069+6+110311,00.html

http://www.madsci.org/posts/archives/mar97/853785360.Ph.r.html

and see whether they give you any help!

Robert Hunt

Always a correct answer?

I desperately need some help and fast. I am an A−level student and have been faced with a 500 word essay on discussing: "The joy of maths is that it always has a correct answer". I've thought of a few things but need more ideas....got any? Thank you!!

Karen

Dear Karen,

As well as Godel's Theorem, which will certainly give you some ideas, you might like to think about the fact that whilst maths problems at SCHOOL are well−understood and the answer is known (by your teacher, for example), most maths problems which are being studied for real by researchers have UNKNOWN answers. So the difficulty is first to decide what the answer is, and then try to prove it.

For example, imagine a connected graph (i.e., a collection of coloured points some of which are joined by lines − which could cross over) Now think about the number of different colours needed to colour in this graph so that no two points which are joined by a line have the same colour. The actual answer for the minimum number of colours needed is not known. So far, all that mathematicians have managed to do is find some estimates ("upper bounds") for the correct answer. They are still trying to work out the real answer, but even rough estimates are useful (because the answer has lots of applications in the real world: for instance mobile phone networks only work because of this kind of maths). You can read more about this at Radio Controlled?, an article in Issue 8 of Plus.

I do hope that you intend to give credit to Plus in your essay for giving you something to think about − otherwise we might be worried that you're cheating!

Good luck!
Yours,
Dr Robert Hunt.
(Editor, Plus)

Galloping Gyroscopes

Firstly, congratulations on your work in bringing this magazine to the web. My question is directed at the authors (Kona Macphee and Hugh Hunt) of an article I recently read about the gyroscopic effect Galloping Gyroscopes. I would much appreciate your passing this message on to either of the authors.

In the section titled "Conservation of Angular Momentum" it is stated that If you now tilt the gyroscope to the vertical, so that its spinning disc is in the horizontal plane, you have transferred its angular momentum to the vertical plane. Since the net angular momentum in this plane must remain zero (to conserve angular momentum − it was zero in this plane when we started) you'll find that you and the chair start spinning to compensate!

The upshot of this statement seems to be that the angular momentum transfer has been cancelled out. If you consider the gyroscope as a part of a larger system (include the person and the chair), why is it that the angular momentum is not simply transferred from the horizontal to the vertical ? I understand that the net effect has to be zero, but you seem to be saying that the angular momentum in the vertical plane has to be re−directed to the horizontal plane.

Any light you can shed on my query will be greatly appreciated. I am trying to get a handle on this topic as I would like to be able to explain why pushing on the right handle bar of a motorcycle causes the bike to veer right.

Peter Metcher

Dear Peter,

The key to understanding this is to realise that angular momentum is a vector quantity, and is conserved as a vector quantity provided no couples act upon the system. It therefore makes sense to look at just the vertical component of this vector − i.e. the angular momentum associated with spin about a vertical axis.

The chair swivels freely on a vertical axis, so the Earth is unable to exert a significant couple on the chair/gyroscope system in this direction. The vertical component of angular momentum of the chair/gyroscope system must therefore be constant.

As the article says, this component was initially zero. If the gyroscope is turned so its axis is vertical, then the gyroscope contributes a non−zero amount to the vertical angular momentum. Since the total must be zero, the chair/sitter has to revolve in the opposite direction, so contributing an exactly balancing negative angular momentum to the system.
Mike

Can I get a printed copy?

Is it possible to have your publication mailed out for every issue or is it a primarily on−line publication?

Triveni Perera

Dear Triveni,

It is primarily an on−line publication, however it should print reasonably well if you select the 'get printable page' version first.

Modelling Problem

I am trying to track down the solution to a problem we face in real life. Its about 20 years since I did maths at University and haven't touched it since, so I was wondering if you could provide the answer or point me to a book / person who may be able to answer.

We're not really the right people to ask, as Plus is a magazine for A−level pupils! But anyway, your problem as stated is possible to solve...

Problem:

Tank full of liquid, volume = VT

Pipework going from tank and returning to tank, volume in pipework = VP

Flow rate of liquid through pipe = F.

This is the current steady state situation.

Then, addition of different material is made to tank.

Question, how long, (tank "turnovers") does it take for the composition of the liquid to become "uniform" again?????

Assumptions:

1. Instantaneous perfect mixing in the tank.
2. No mixing in the pipework.

Real situation, VP= approx 0.6VT. Tank is stirred.

Paul Adeney

Let the volume fraction of the "different material" in the tank be $\alpha(t)$ at any time t. In a small time−interval δt, a volume of fluid $F \times \delta t$ leaves the tank, i.e. an amount $\alpha(t) \times F \times \delta t$ of the "different material" leaves the tank. However, it is replaced by $F \times \delta t$ of new fluid from the pipe, which contains an amount of the "different material" given by $\alpha(t - VP/F) \times F \times \delta t$. (This is because the fluid takes a time VP/F to move through the pipework, and no mixing occurs in the pipes.)

Hence the new volume fraction is

$$\alpha(t+\delta t) = \frac{\alpha(t) \times VT - \alpha(t) \times F \times \delta t + \alpha(t - VP/F) \times F \times \delta t}{VT},$$

which means (using elementary calculus) that

$$\frac{d\alpha}{dt} = (F/VT) \times (\alpha(t - VP/F) - \alpha(t)).$$

This differential equation is only valid when $t > VP/F$ − to start with, there is clean liquid in the pipes and so for $t \leq VP/F$ we have instead

$$\frac{d\alpha}{dt} = -(F/VT) \times \alpha(t).$$

These differential equations can be solved analytically, but itâ€™s a bit messy. Itâ€™s probably easier to solve them on a computer instead. However, of course, the fluid is NEVER perfectly "uniform" again, but merely approaches uniformity! Hence the new volume fraction is

$$\alpha(t+\delta t) = \frac{\alpha(t) \times VT - \alpha(t) \times F \times \delta t + \alpha(t - VP/F) \times F \times \delta t}{VT}.$$

Yours, Robert Hunt. (Editor, Plus)

Application of Number

I am a lecturer specialising in teaching Application of Number. I am rather concerned that this is the Year of Mathematics, but the emphasis seems to be on higher level maths and not on the Application of Number (as in Key Skills). Do you know of anyone who is working in this area? I am keen to get networking!!

Lynn Tranter

Dear Lynn,

Start with the NRICH website and NRICH Primary website. Then follow the link to 'Other Maths Sites'.

Plus is aimed at 'A' level and up. NRICH does have quite a bit of number work.

Mike

Plus is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.