

?Discovery-based? Learning Pushes Students Over the Threshold

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The divergence theorem $\int_V \nabla \cdot \mathbf{v} \, dV = \oint_S \mathbf{v} \cdot \hat{\mathbf{n}} \, dS$

It relates to how much things 'spread out'

- Air or other gasses
- Liquids
- Heat or other energy
- Mass
- Momentum
- Force fields
- Electric fields

Engineers need to understand and use it



The divergence theorem $\int_V \nabla \cdot \mathbf{v} \, dV = \oint_S \mathbf{v} \cdot \hat{\mathbf{n}} \, dS$

It's not a *basic* concept

"It's
scary"

It's a *threshold* concept

- Transformative
- Irreversible
- Integrative
- Bounded
- Troublesome

(Land and Meyer, 2003)



Lecture activity: divergence theorem

- Please blow up your balloon a bit
- Then tell your neighbour what you estimate the volume is
- Any unit of measurement is ok – e.g.
 - half a pint?
 - 175 cl?
 - 330 ml?
 - $\frac{1}{2}$ a litre?
 - 200 cm^3

Lecture activity: divergence theorem

- This is called the 'initial' volume estimate
- Linda's initial volume estimate = 100 ml
- Try to remember yours
- Don't let go!

Lecture activity: divergence theorem

- Now blow again for exactly 3 seconds, and estimate the new volume
- This new estimate is called is the 'final' volume

Lecture activity: divergence theorem

- Linda's final volume is 1,000 *ml*
- What's yours?

Lecture activity: divergence theorem

- Question 1: How much did the balloon expand by?
- Hint: calculate the difference between the two volumes
- Linda's initial volume = 100 ml
- Linda's final volume = $1,000 \text{ ml}$
- Final – initial = $1,000 - 100 = 900 \text{ ml}$

Lecture activity: divergence theorem

- Question 2: Now calculate the rate of expansion

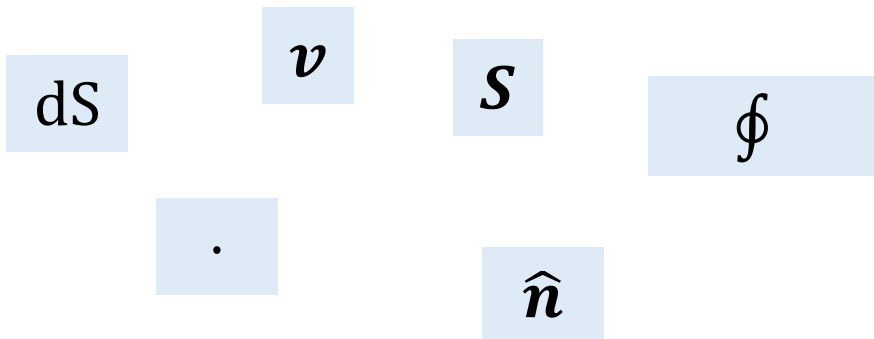
• Hint: it's $\frac{\textit{the difference between the two volumes}}{\textit{the time it took (3 seconds)}} = \frac{\textit{final - initial}}{\textit{time}}$

• Linda's rate = $\frac{1000-100}{3} = \frac{900}{3} = 300 \textit{ ml per second}$

- What was your rate? (We are done with the balloons now 😊)

Question for students in the lecture....

- Question: How can you combine the six symbols below to represent mathematically what you just calculated, as a flux integral?



- Answer:

$$\oint_S \mathbf{v} \cdot \hat{\mathbf{n}} \, dS$$

- This is a major component of the divergence theorem

$$\int_V \nabla \cdot \mathbf{v} \, dV = \oint_S \mathbf{v} \cdot \hat{\mathbf{n}} \, dS$$

Question to you...

- Is this balloon lecture activity ‘discovery-based learning’?

PG Diploma in University Learning & Teaching assignment

Develop a narrative argument about both the relevancy and limitations of 'Threshold Concepts Theory' when applied to your educational setting

*I discovered that the divergence theorem is a *threshold concept* in my teaching*

Discovery-based Learning Pushes Students Over the Threshold.....Thank you for listening

- Balloon lecture activity: not discovery-based learning
 - relating an actual object to mathematical symbols $\int_V \nabla \cdot \mathbf{v} \, dV = \oint_S \mathbf{v} \cdot \hat{\mathbf{n}} \, dS$
 - the social interaction
- PGDip 'writing critically' assignment: discovery-based elements
 - critical writing skills
 - threshold concept theory
 - I discovered a threshold concept in my teaching,
 - and consequently designed the balloon activity to scaffold crossing the threshold