Title: Physics in Nature Presentation: Estimating the Speed of a Swimming Duck

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URL: http://pirsa.pi.local/11080104

Abstract:

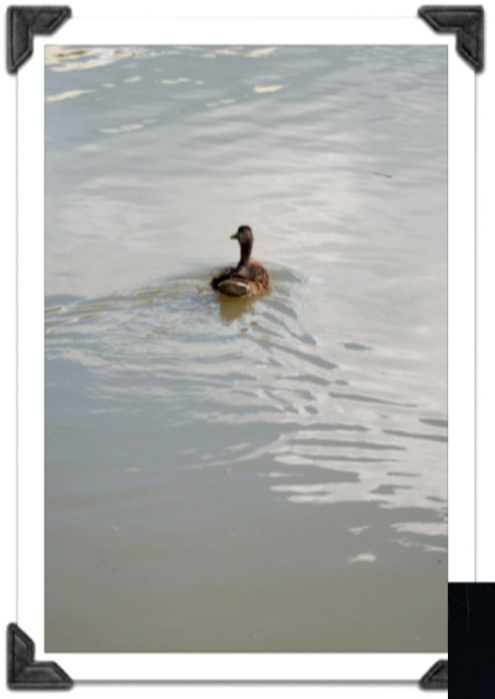
DUCK RACING

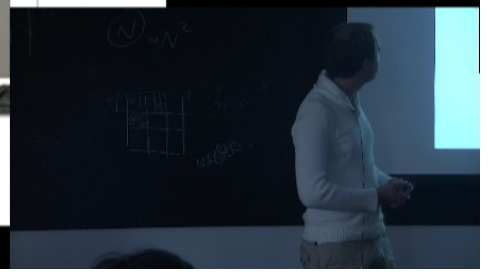
Estimating the speed of a swimming duck

Henrik Gustafsson

INSPIRATION

- Obtain information from sparse data





INSPIRATION

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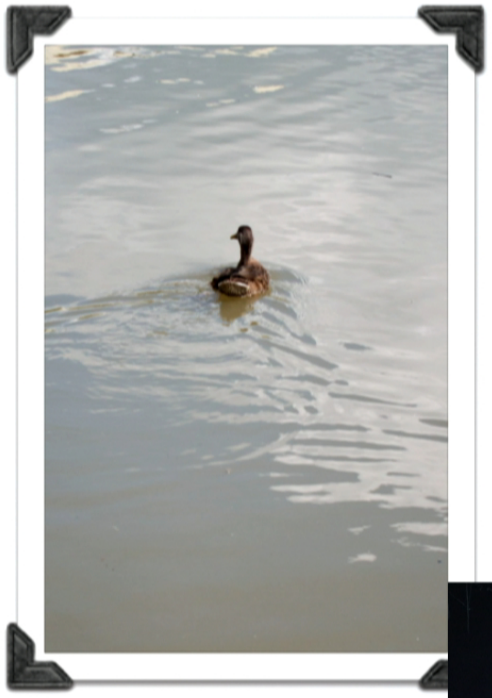
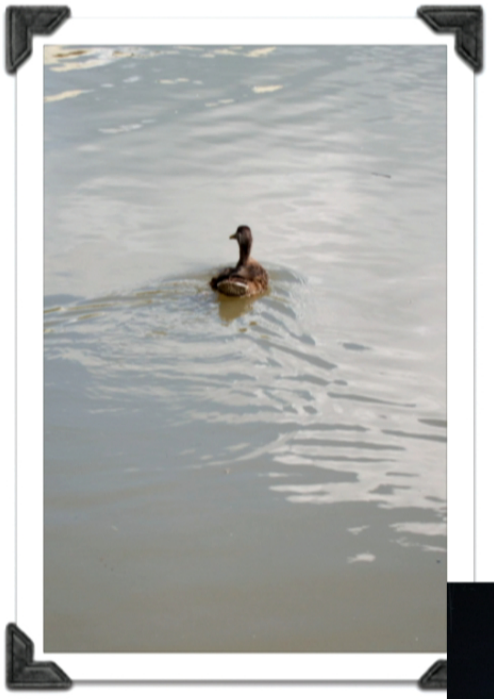


INSPIRATION

- Obtain information from sparse data
- Measure quantity indirectly



APPROACH

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- Geometry

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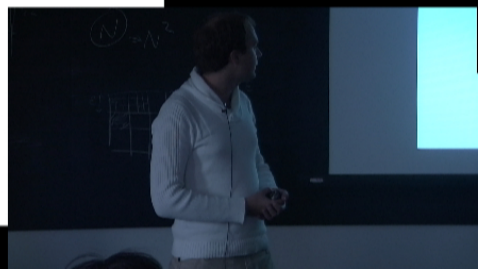
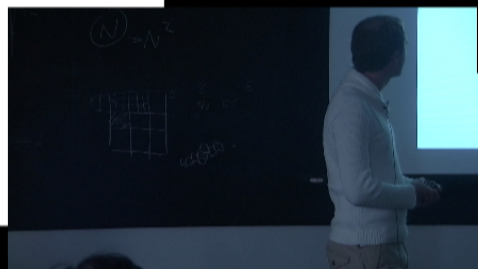
- Geometry
- Wave properties



GEOMETRY

v_d : duck speed $\quad$ v_w : phase speed



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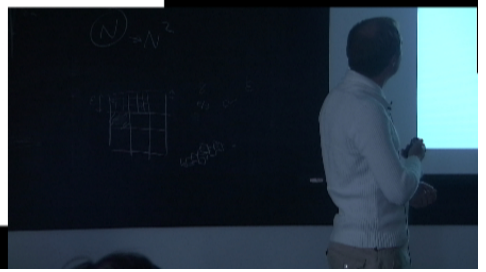
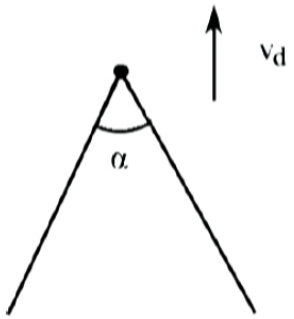


GEOMETRY

- Point like duck



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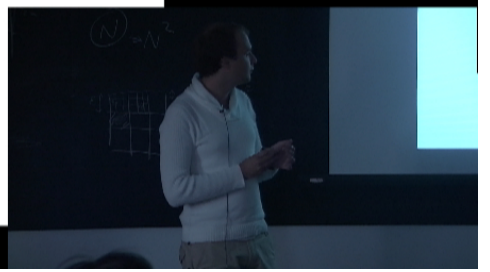
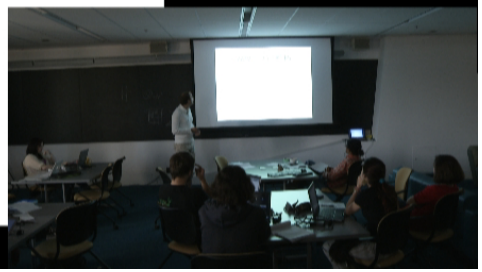


WAVE PROPERTIES

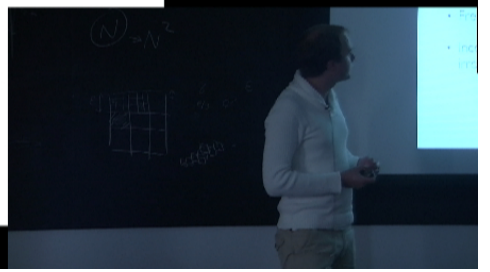
- Assumptions



WAVE PROPERTIES

- Assumptions
  - Small amplitude
  - Freely propagating
  - Incompressible and irrotational

$$\nabla \cdot \mathbf{u} = 0 \qquad \text{incompressible}$$
$$\nabla \times \mathbf{u} = 0 \qquad \text{irrotational}$$



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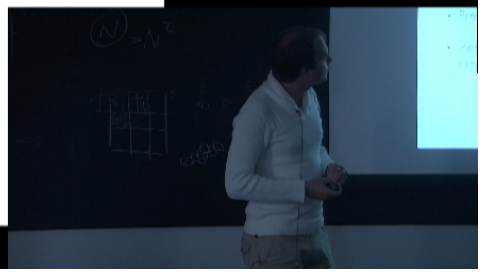
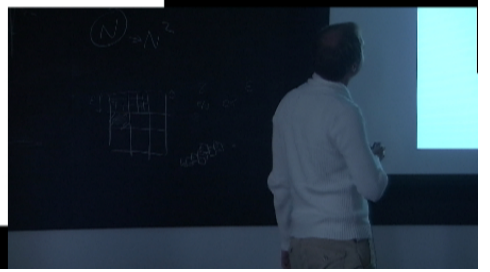


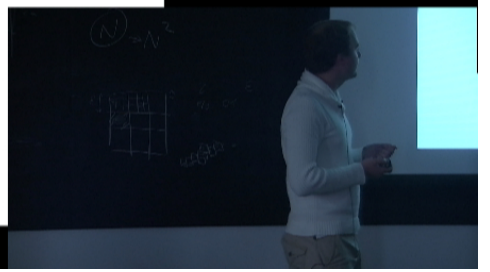
WAVE PROPERTIES

- Conditions



WAVE PROPERTIES

- Conditions
  - Bottom boundary condition



WAVE PROPERTIES

- Conditions
  - Bottom boundary condition $u_z = 0 \quad \text{at } z = -d$
  - Surface boundary condition $u_z = \frac{d\eta}{dt} \quad \text{at } z = \eta$

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- Conditions
  - Bottom boundary condition $u_z = 0 \quad \text{at } z = -d$
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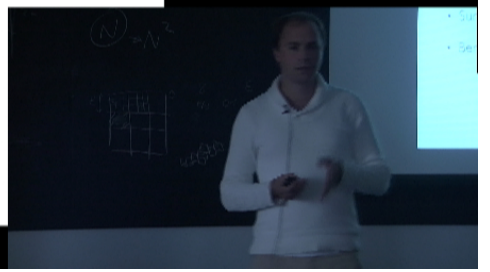
  - Bernoulli's eq. for irrotational flow



WAVE PROPERTIES

- Assume small amplitude waves, linearize the extra conditions and apply them to a still water line $z = 0$

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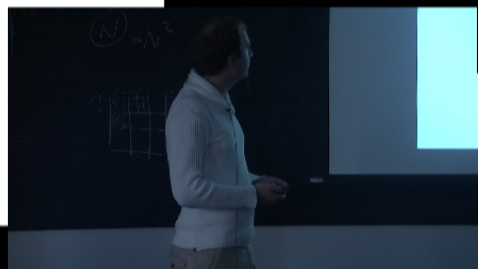
- Assume small amplitude waves, linearize the extra conditions and apply them to a still water line $z = 0$
- Solve for the wave form η and find the phase speed as [1]



APPLICATION

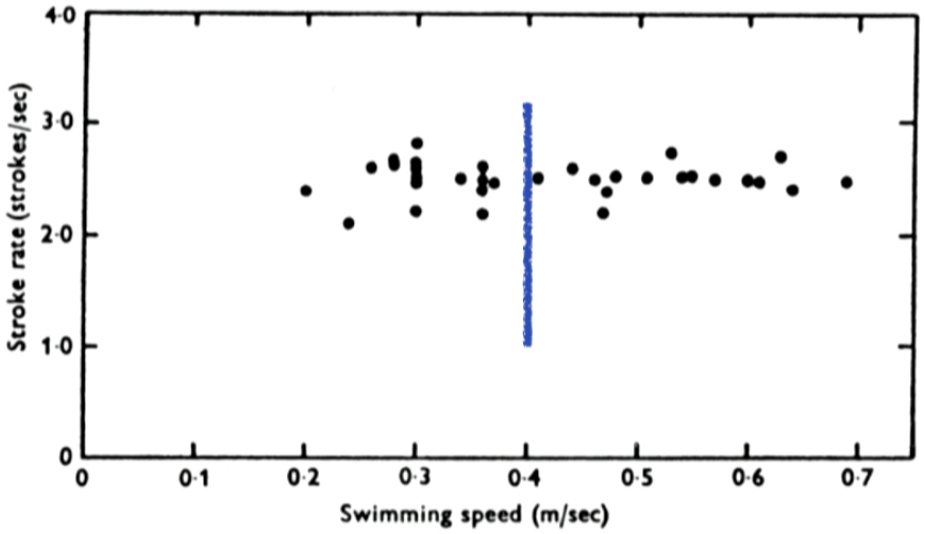
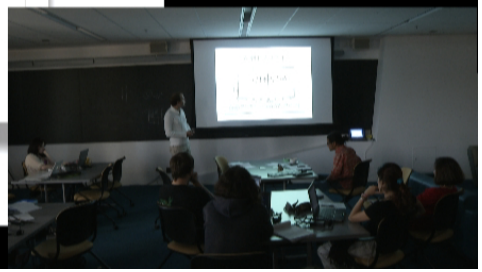


Fig. 7. Stroke rate of duck's feet at various swimming speeds. A linear least squares regression line for the data has the equation: Strokes/sec = $2{\cdot}44 + (1{\cdot}14 \times 10^{-4} \times$ swimming speed, m/sec).

Source: *Readings in animal energetics*, Robert H. Catlett, Ardent Media, 1973



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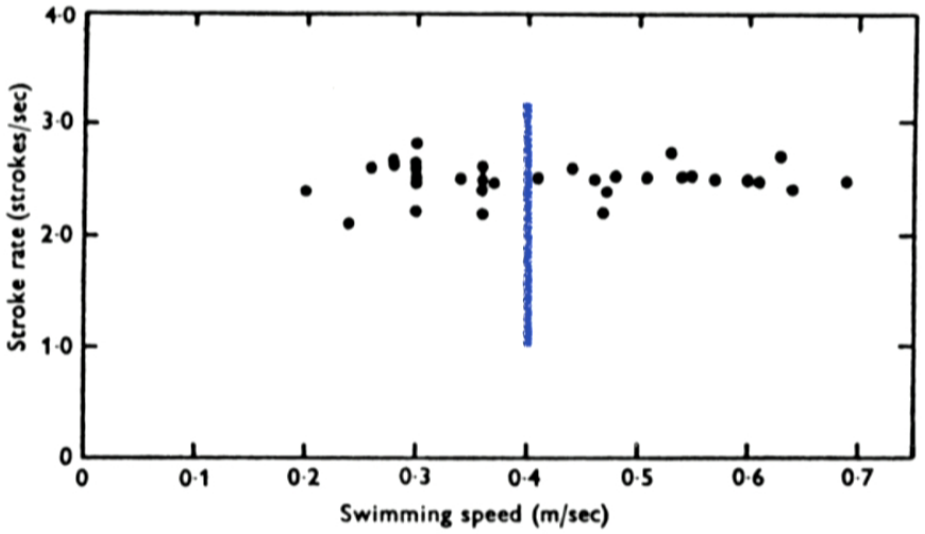

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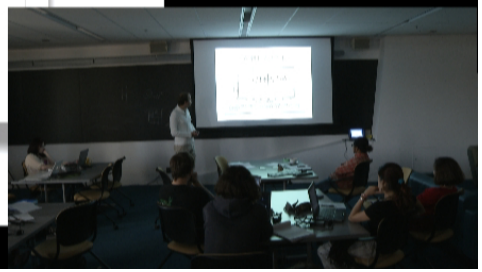

SUMMARY

- Geometry
- Wave properties
- Application