Can a bubble sink a Ship?

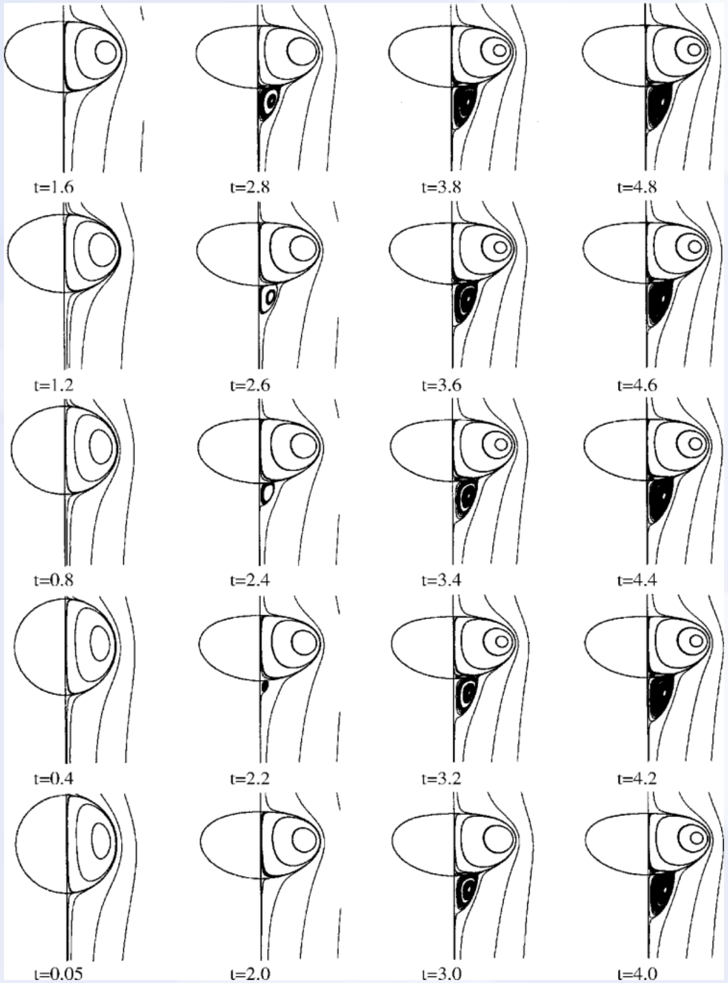
By Dvir Flom

The Incentives

- 2000 – the Skandi Inspector finds an early 20th century trawler, upright in 'Witches Hole'.
- Modern day Oil Rigs also suffer from sudden and unpredictable eruptions of methane pockets.

Problem (Part I) – The Bubble

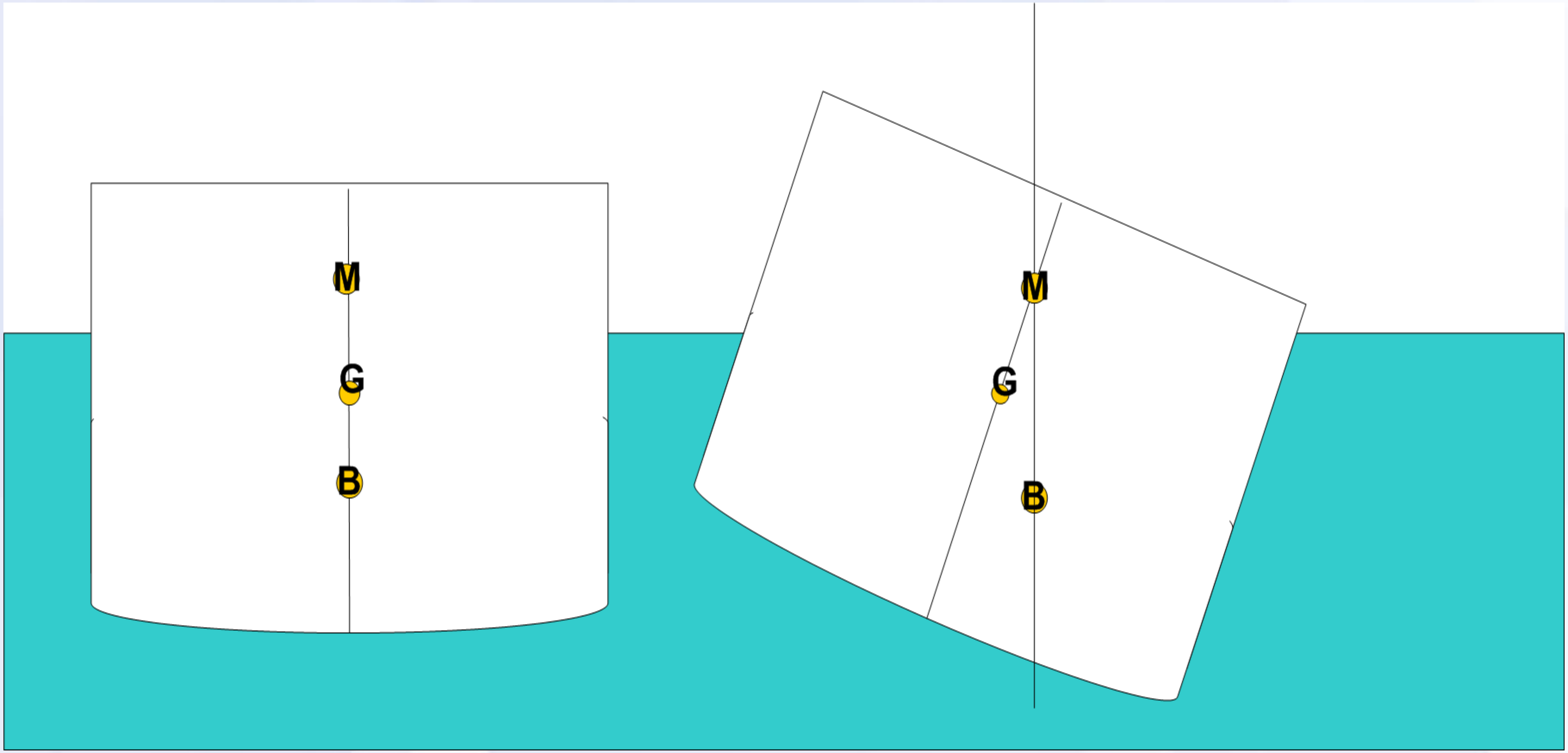
- Describing the rise of the Bubble:
  - Pressure change
  - Shape



Problem (Strikes Back) – Ship

- Solid interacting with liquids
- Drowning criteria (where bad is good)-
  - Sliding into ripple
  - Free fall
  - Wave crash (water filled hull)

Capsize (Roll angle) Criteria



Solution

- SPH model -

$$A(r,h) = \sum m_b \frac{a_b}{\rho_b} W(r - r_b, h)$$

$$\nabla A(r,h) = \sum m_b \frac{a_b}{\rho_b} \nabla W(r - r_b, h)$$

$$Navier-Stokes: \frac{dv}{dt} = -\nabla \frac{P}{\rho} - \frac{P}{\rho^2} + \frac{\mu}{\rho} \nabla^2 v + \boldsymbol{F}$$

$$\frac{dv_a}{dt} = -\sum m_b \left(\frac{P_a}{\rho_a^2} + \frac{P_b}{\rho_b^2} + \prod_{ab} \right) \nabla_a W_{ab} + \boldsymbol{F_a}$$

Solution

- Free Surface $\frac{d\rho_a}{dt} = \sum m_b (\boldsymbol{v}_b - \boldsymbol{v}_a) \cdot \nabla_a W_{ab} = D_a$

The Equations

- Motion

$$\frac{dv_a}{dt} = f_a ; \frac{d\square_a}{dt} = D_a ; \frac{dr_a}{dt} = v_a ;$$

Prediction

$$\boldsymbol{v}\square_a = \boldsymbol{v}_a^i \square \square t \, \boldsymbol{f}_a^i$$

$$\square_a = \square_a^i \square \square t \, D_a^i$$

$$\boldsymbol{r}\square_a = \boldsymbol{r}_a^i \square \square \boldsymbol{v}_a^i \square \frac{1}{2} \square\square t \, {}^2 \square \boldsymbol{f}_a^i = \boldsymbol{r}_a^{i \square 1}$$

Correction

$$\boldsymbol{v}_a^{i \square 1} = \boldsymbol{v}_a^i \square \frac{1}{2} \square t \square \boldsymbol{f}_a^i \square \boldsymbol{f}\square_a \square$$

$$\square_a^{i \square 1} = \square_a^i \square \frac{1}{2} \square t \square D_a^i \square D\square_a \square$$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