H&H Essentials

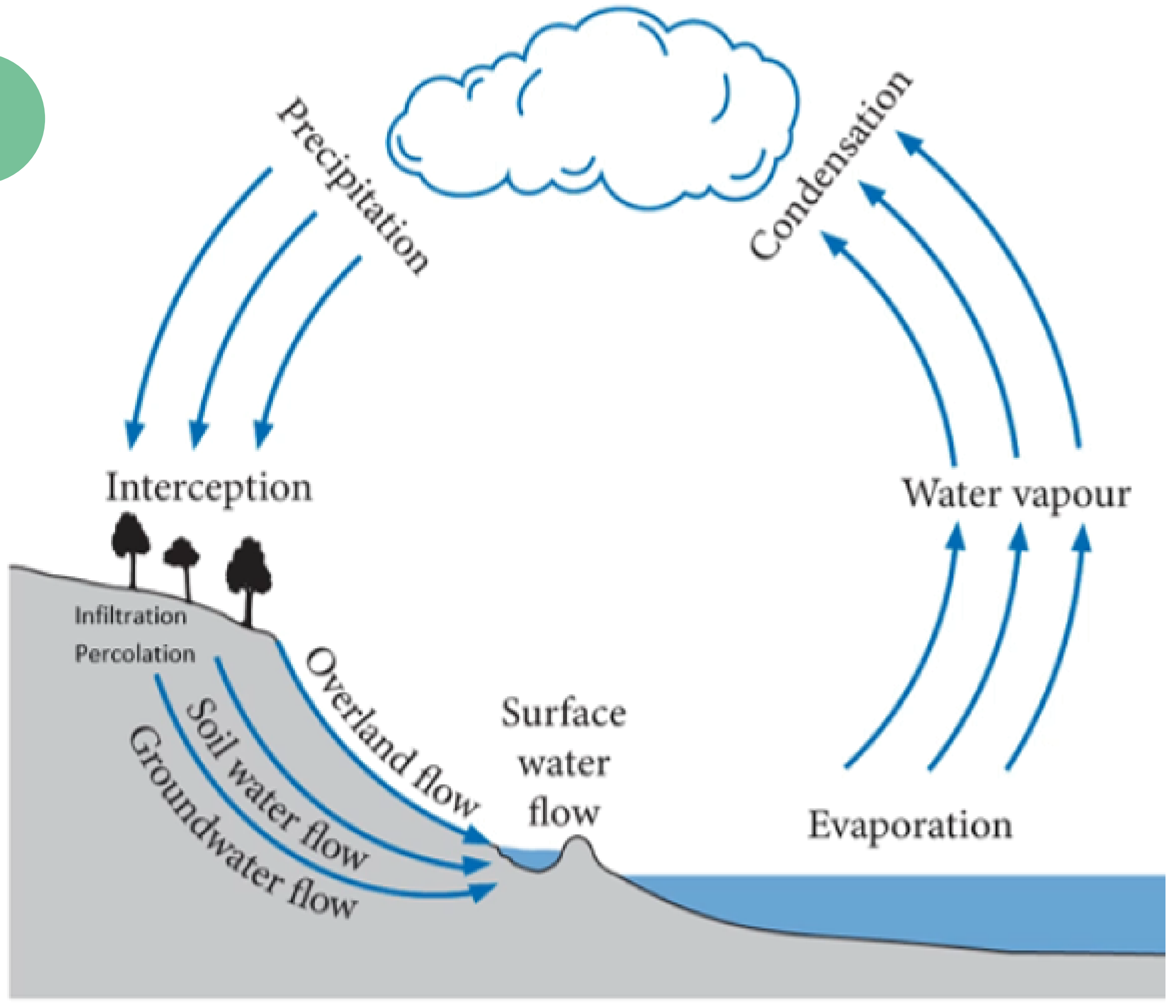
From First Principles to Engineering Applications

Course Date	Surface Water Hydrology: Quantification of Flow
5 May	1. Meteorology and precipitation
12 May	2. Infiltration and losses
19 May	3. Flow routing
26 May	4. Stochastic hydrology
	Surface Water Hydraulics: Characterisation of Flow
9 Jun	5. Hydrostatics and open channel flow
16 Jun	6. 1D, 2D, and 3D flow
23 Jun	7. Pipe flow and hydraulic structures
30 Jun	8. Flood hazard, scour and sedimentation

H&H Essentials

From First Principles to Engineering Applications

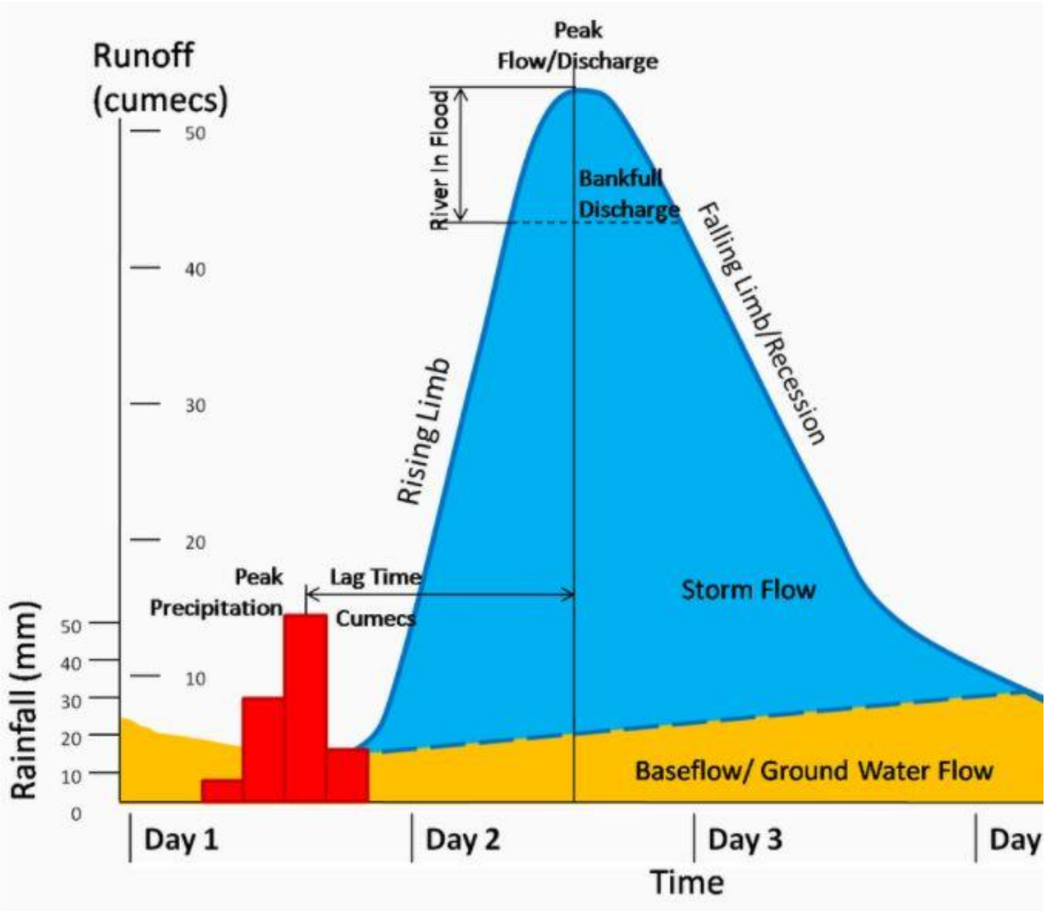
Course Date	Surface Water Hydrology: Quantification of Flow
5 May	1. Meteorology and precipitation
12 May	2. Infiltration and losses
19 May	3. Flow routing
26 May	4. Stochastic hydrology
	Surface Water Hydraulics: Characterisation of Flow
9 Jun	5. Hydrostatics and open channel flow
16 Jun	6. 1D, 2D, and 3D flow
23 Jun	7. Pipe flow and hydraulic structures
30 Jun	8. Flood hazard, scour and sedimentation



H&H Essentials

From First Principles to Engineering Applications

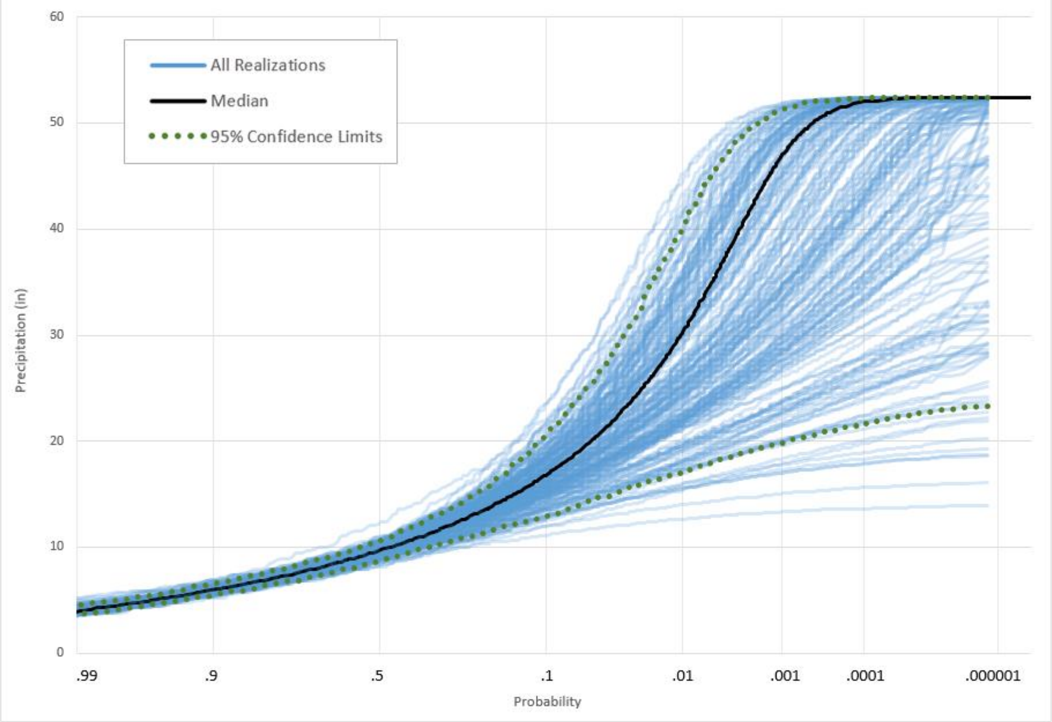
Course Date	Surface Water Hydrology: Quantification of Flow
5 May	1. Meteorology and precipitation
12 May	2. Infiltration and losses
19 May	3. Flow routing
26 May	4. Stochastic hydrology
	Surface Water Hydraulics: Characterisation of Flow
9 Jun	5. Hydrostatics and open channel flow
16 Jun	6. 1D, 2D, and 3D flow
23 Jun	7. Pipe flow and hydraulic structures
30 Jun	8. Flood hazard, scour and sedimentation



H&H Essentials

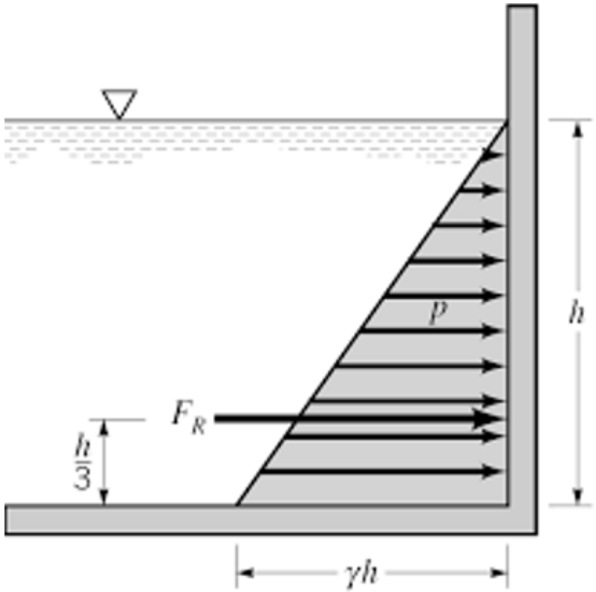
From First Principles to Engineering Applications

Course Date	Surface Water Hydrology: Quantification of Flow
5 May	1. Meteorology and precipitation
12 May	2. Infiltration and losses
19 May	3. Flow routing
26 May	4. Stochastic hydrology
	Surface Water Hydraulics: Characterisation of Flow
9 Jun	5. Hydrostatics and open channel flow
16 Jun	6. 1D, 2D, and 3D flow
23 Jun	7. Pipe flow and hydraulic structures
30 Jun	8. Flood hazard, scour and sedimentation



H&H Essentials

From First Principles to Engineering Applications

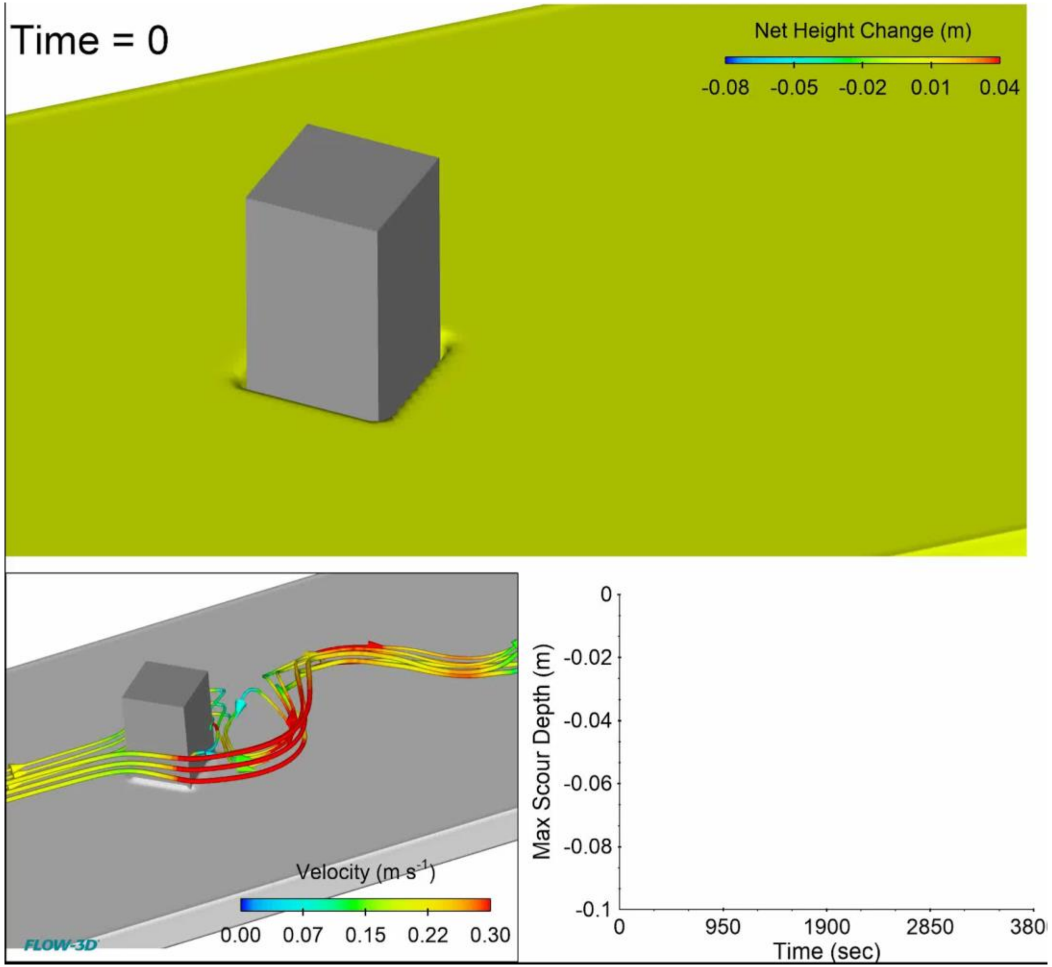


H&H Essentials

From First Principles to Engineering Applications

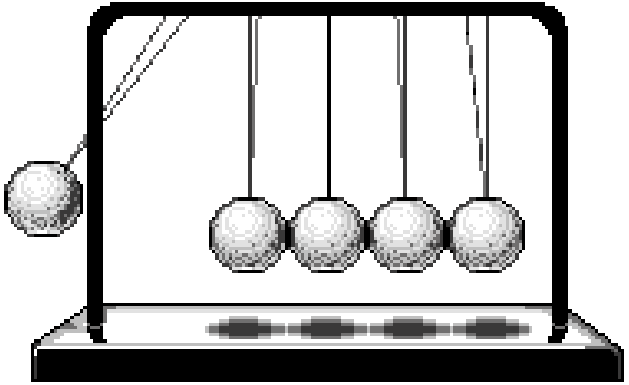
Surface Water Hydraulics: Characterisation of Flow

9 Jun	5. Hydrostatics and open channel flow
16 Jun	6. 1D, 2D, and 3D flow
23 Jun	7. Pipe flow and hydraulic structures
30 Jun	8. Flood hazard, scour and sedimentation



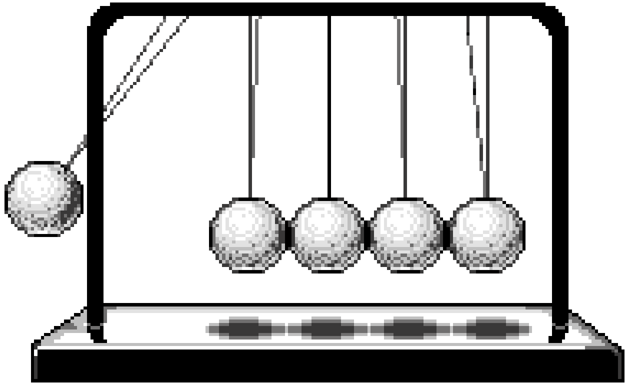
H&H Essentials

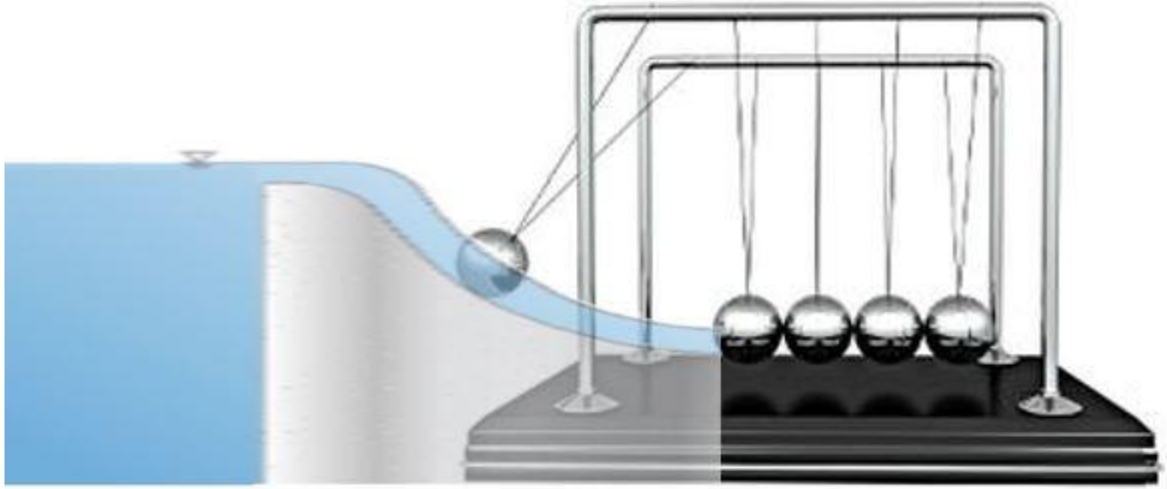
From First Principles to Engineering Applications



H&H Essentials

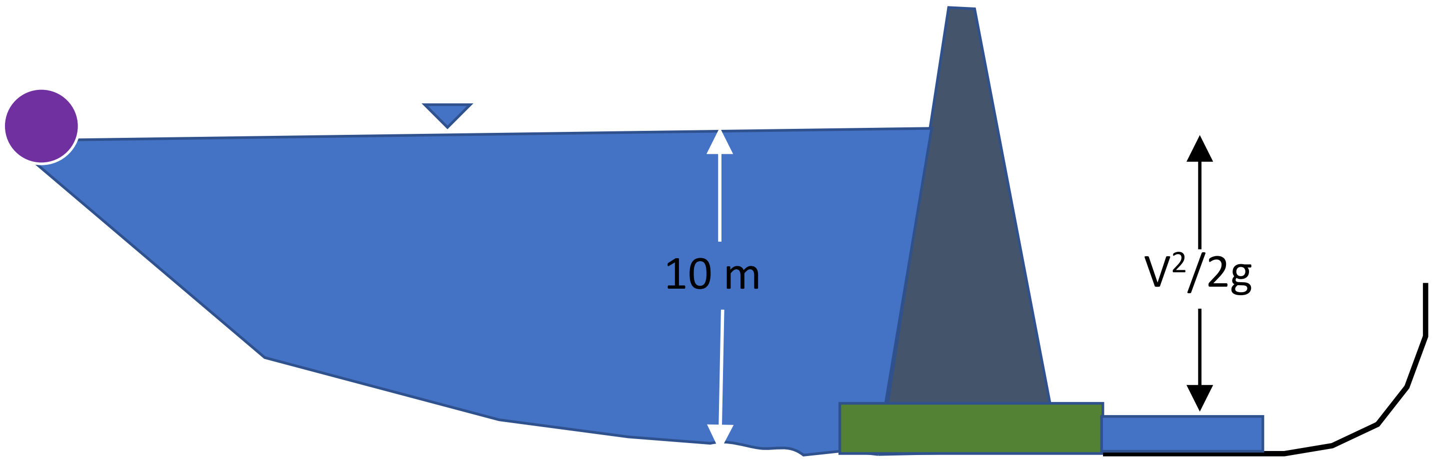
From First Principles to Engineering Applications



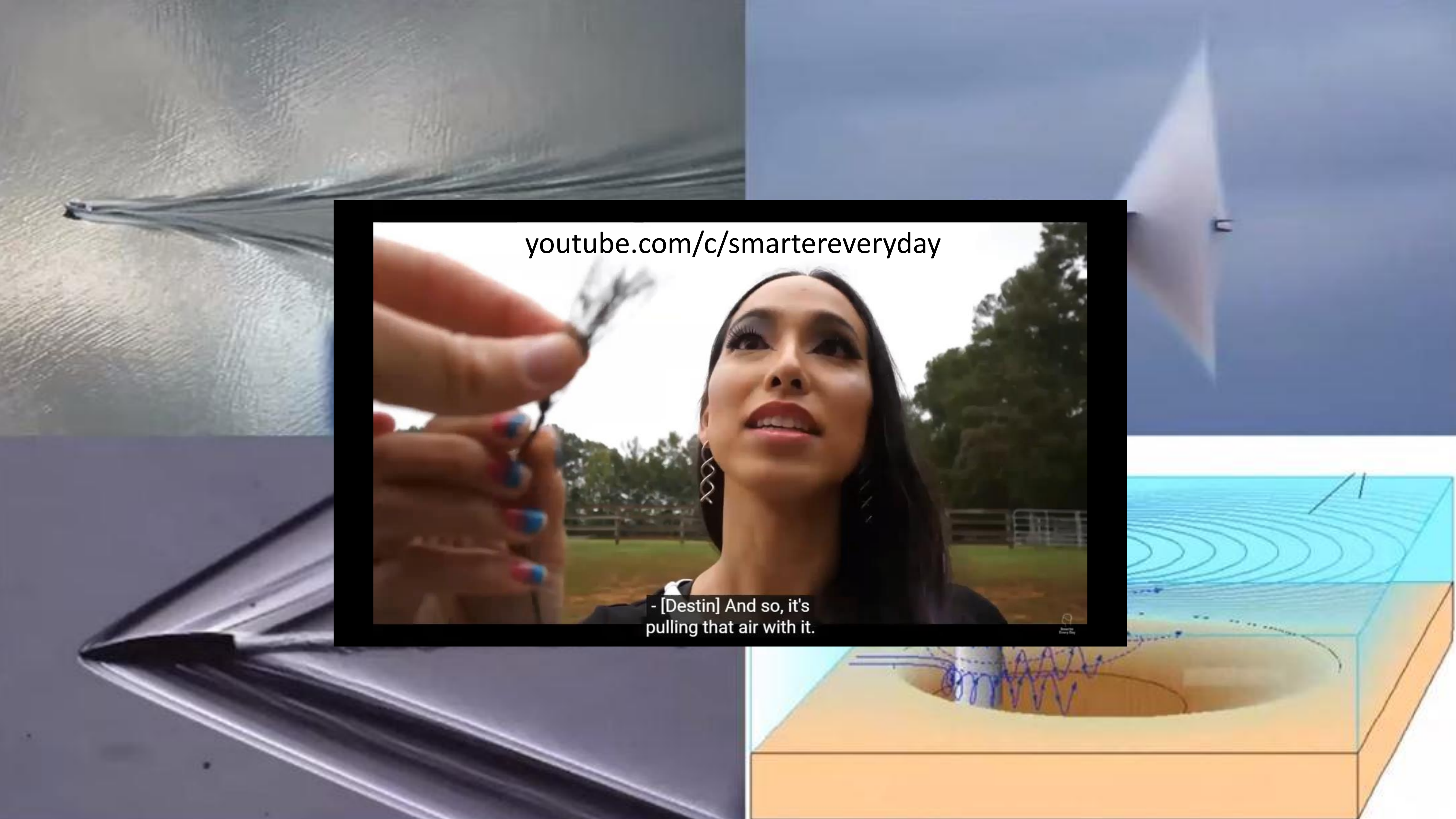


H&H Essentials

From First Principles to Engineering Applications




Froude Dude!


youtube.com/c/smartereveryday
- [Destin] And so, it's
pulling that air with it.

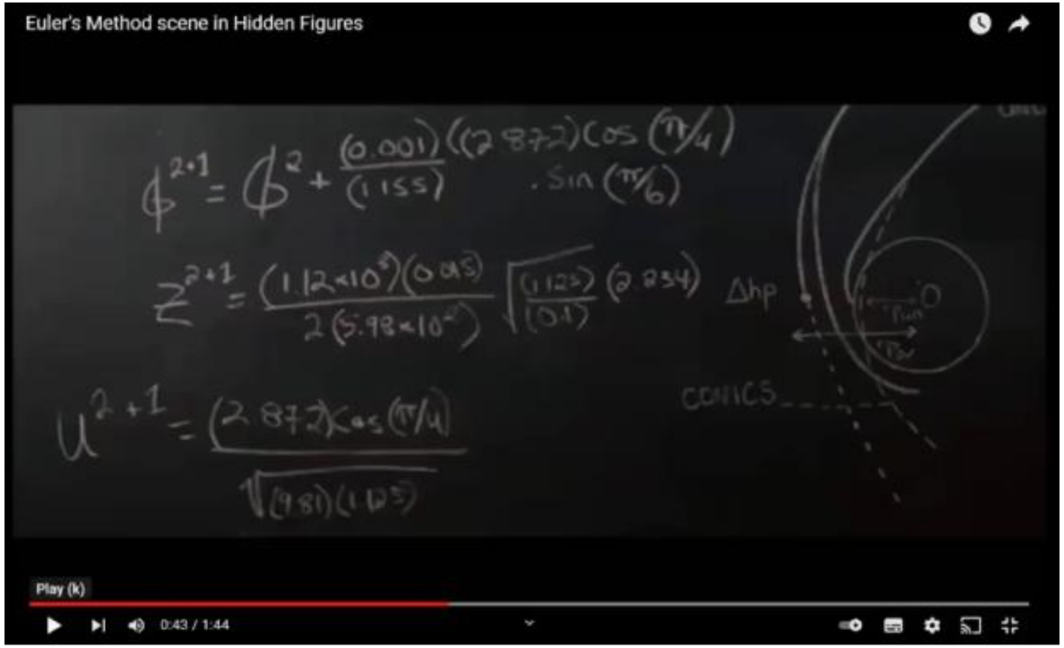
Euler

Poll Question

Does Euler rhyme with?

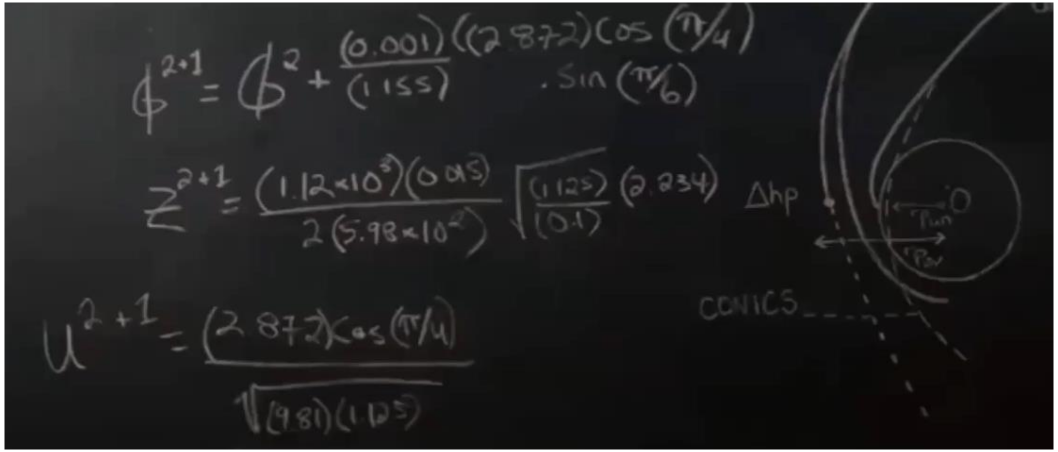
- Bueller
- Boiler

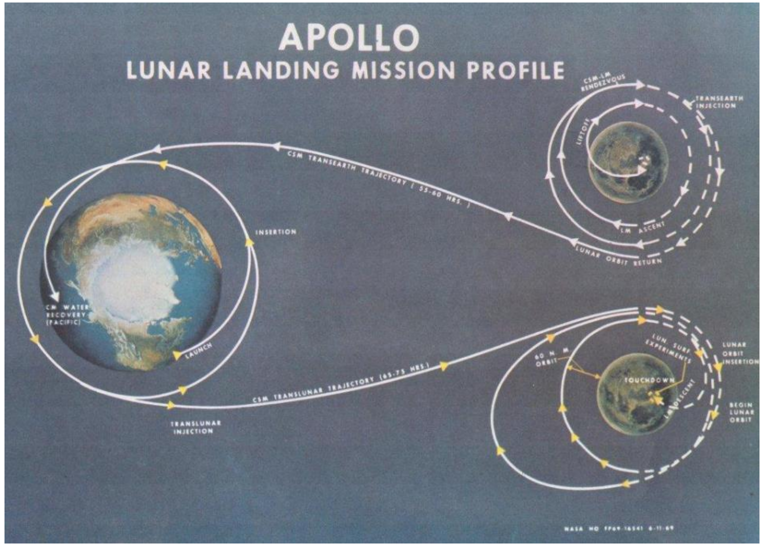
Leonhard Euler
(1707 – 1783)

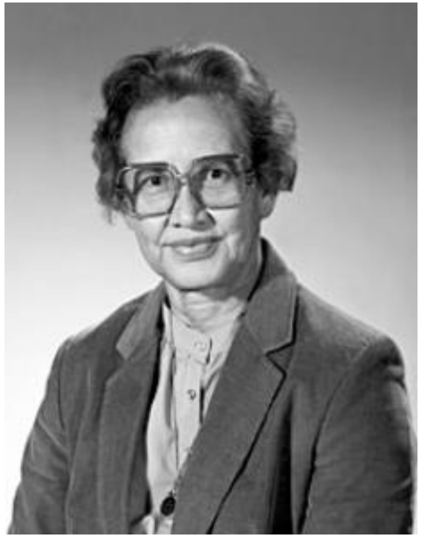


Euler

Answer

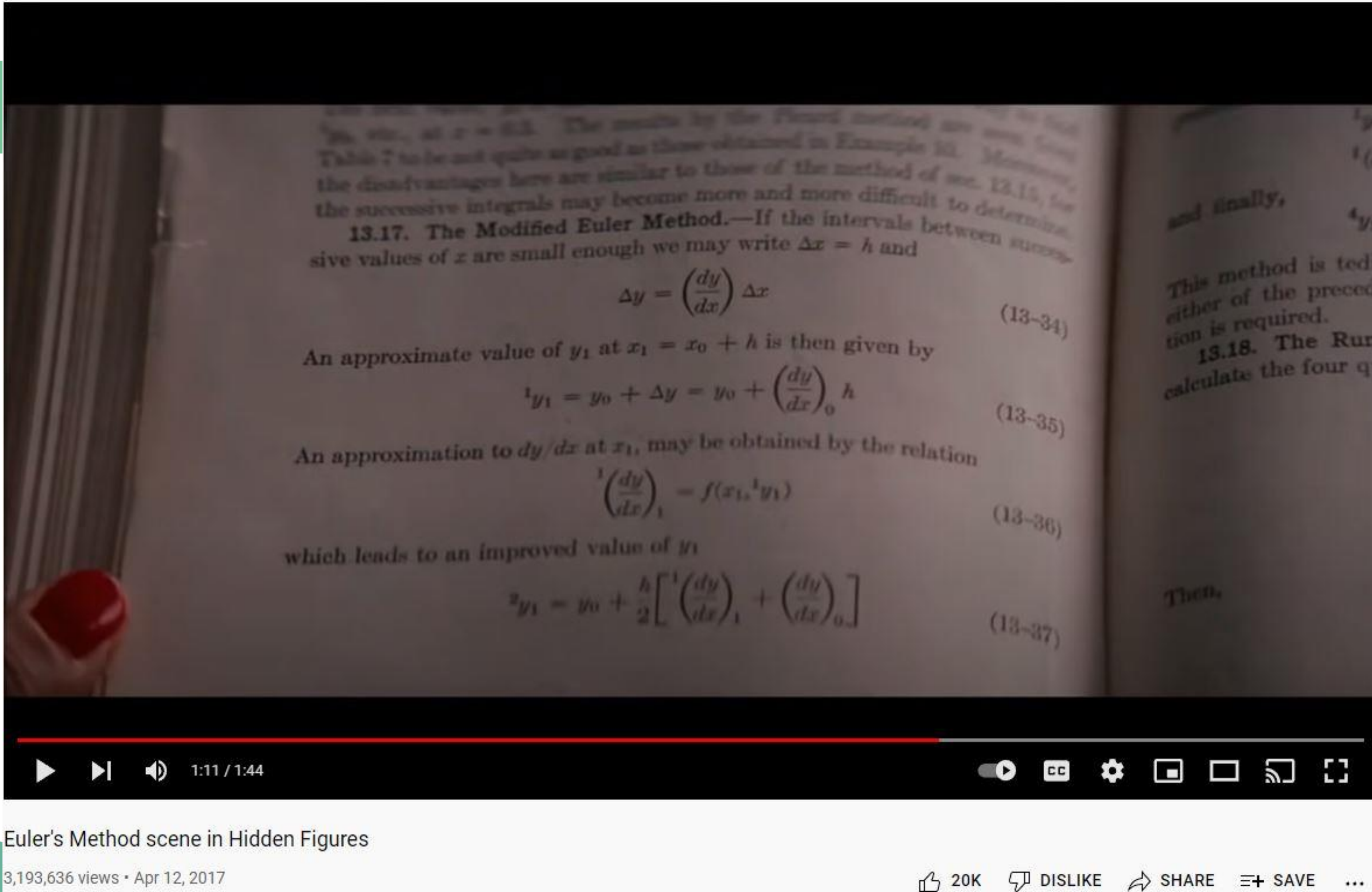






Katherine Johnson
(1918 – 2020)

Euler

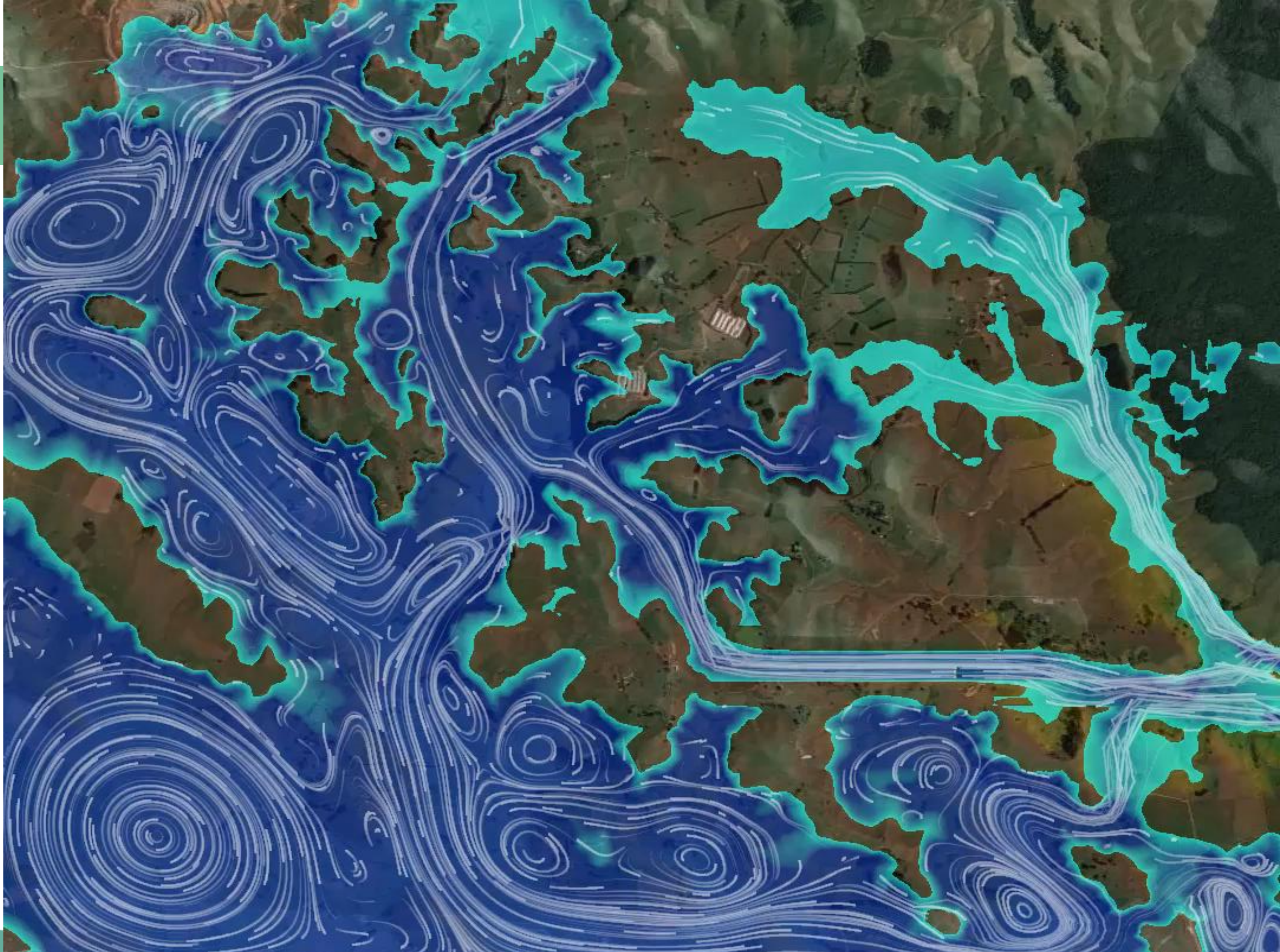


13.17. The Modified Euler Method.—If the intervals between succes-
sive values of x are small enough we may write $\Delta x = h$ and
$\Delta y = \left(\frac{dy}{dx}\right) \Delta x$ (13-34)
An approximate value of y_1 at $x_1 = x_0 + h$ is then given by
${}^1y_1 = y_0 + \Delta y = y_0 + \left(\frac{dy}{dx}\right)_0 h$ (13-35)
An approximation to dy/dx at x_1, may be obtained by the relation
${}^1\left(\frac{dy}{dx}\right)_1 = f(x_1, {}^1y_1)$ (13-36)
which leads to an improved value of y_1
${}^2y_1 = y_0 + \frac{h}{2}\left[{}^1\left(\frac{dy}{dx}\right)_1 + \left(\frac{dy}{dx}\right)_0\right]$ (13-37)
and finally,
tion is required.
Then,
1:11 / 1:44
Euler's Method scene in Hidden Figures
3,193,636 views • Apr 12, 2017
20K
DISLIKE
SHARE
SAVE

Euler

Implicit
or Explicit

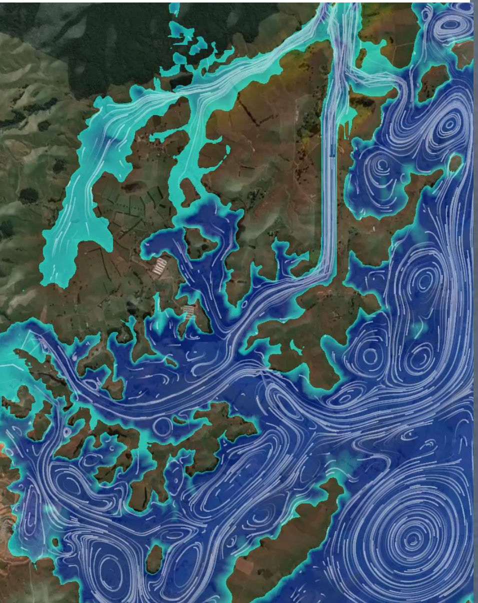
Eulerian or
Lagrangian?

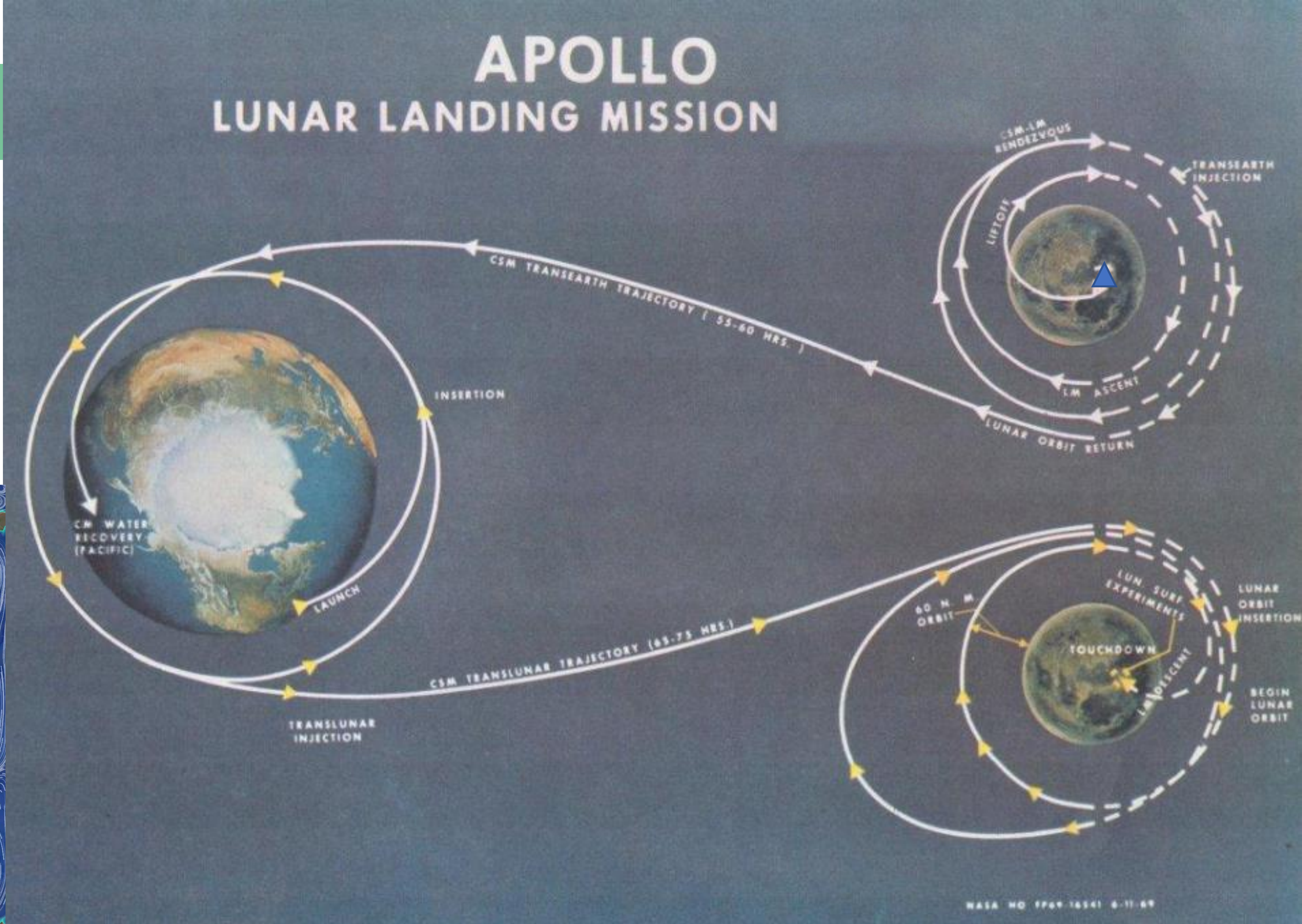


Euler

Implicit
or Explicit

Eulerian or
Lagrangian?

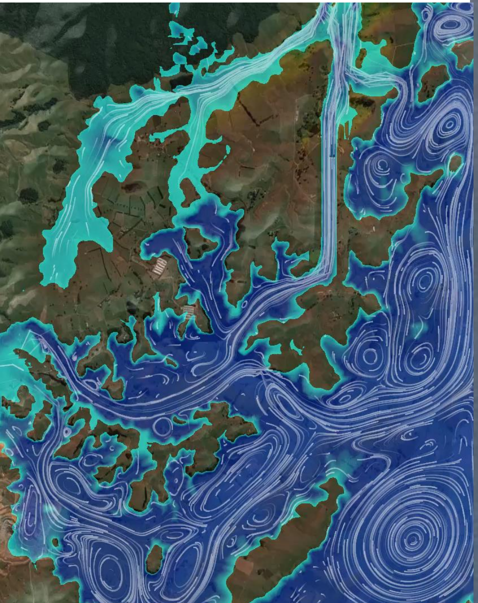


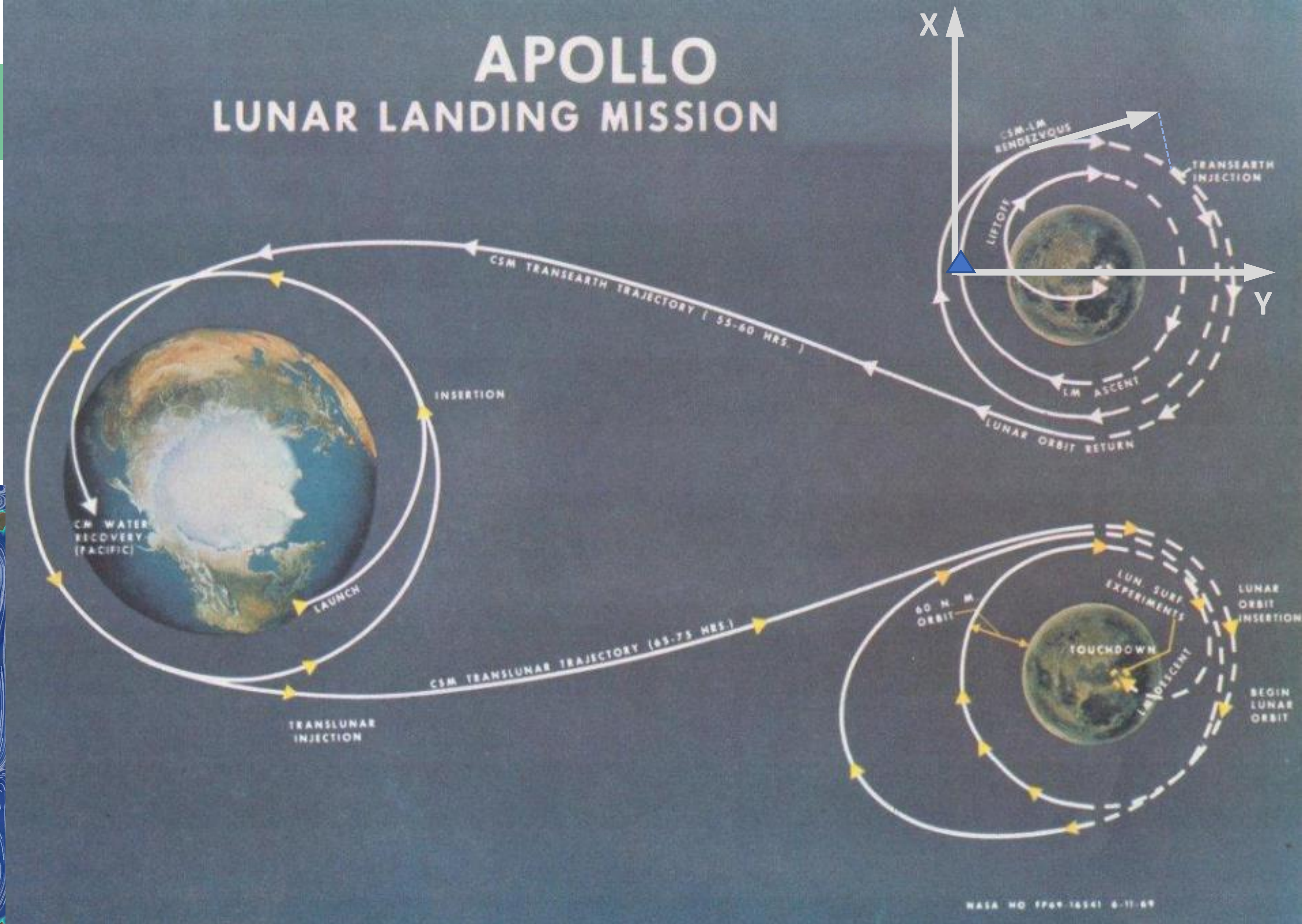


Euler

Implicit
or Explicit

Eulerian or
Lagrangian?

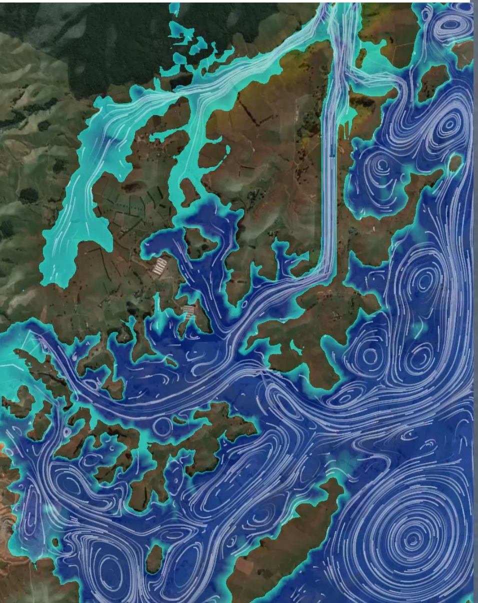


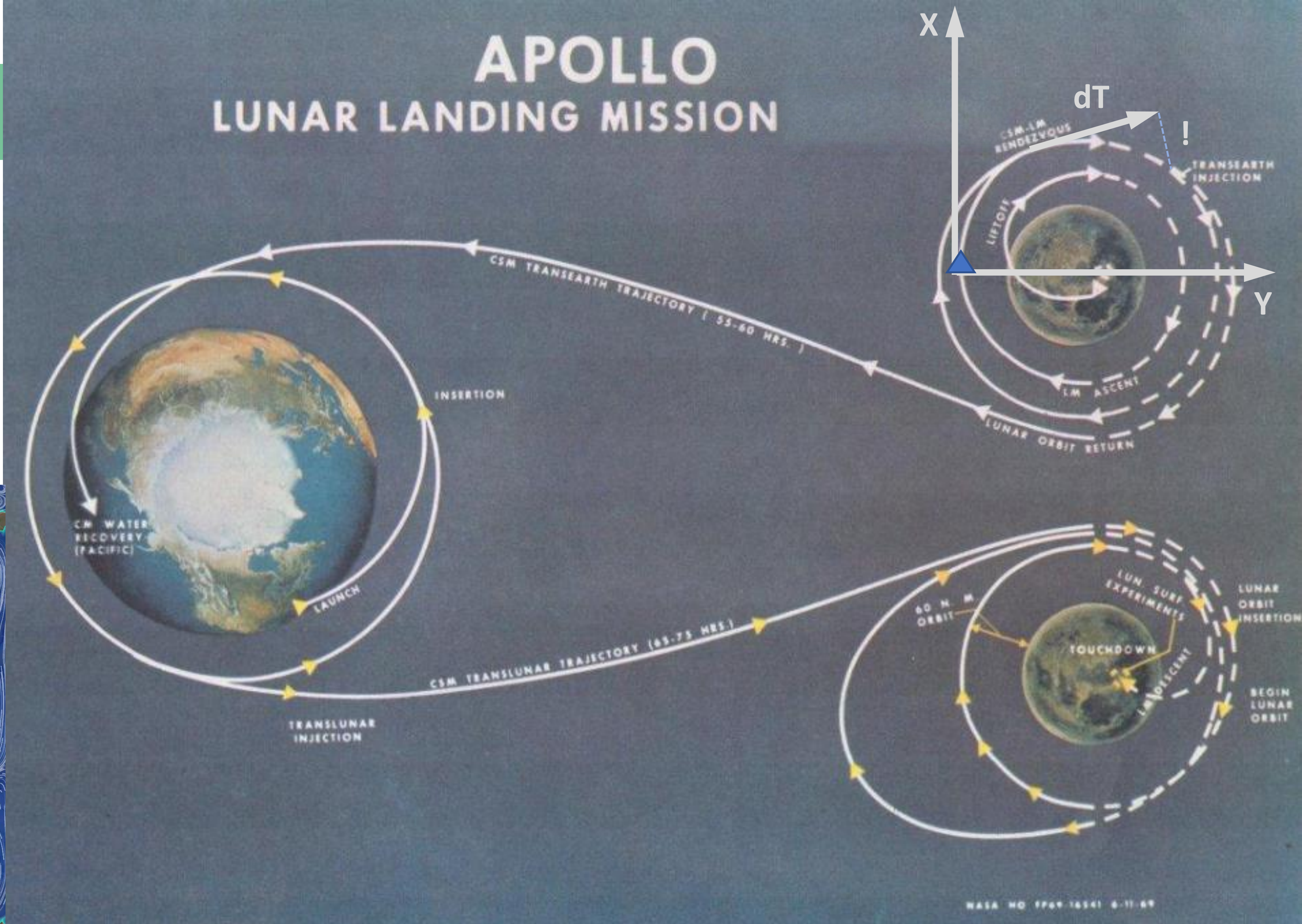


Euler

Implicit
or Explicit

Eulerian or
Lagrangian?

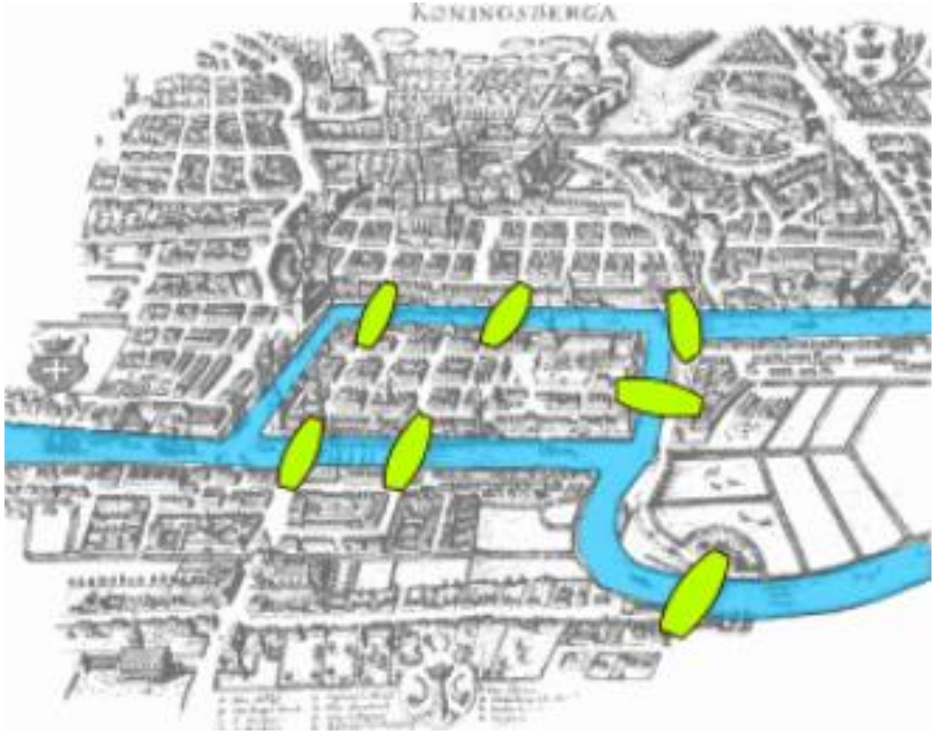




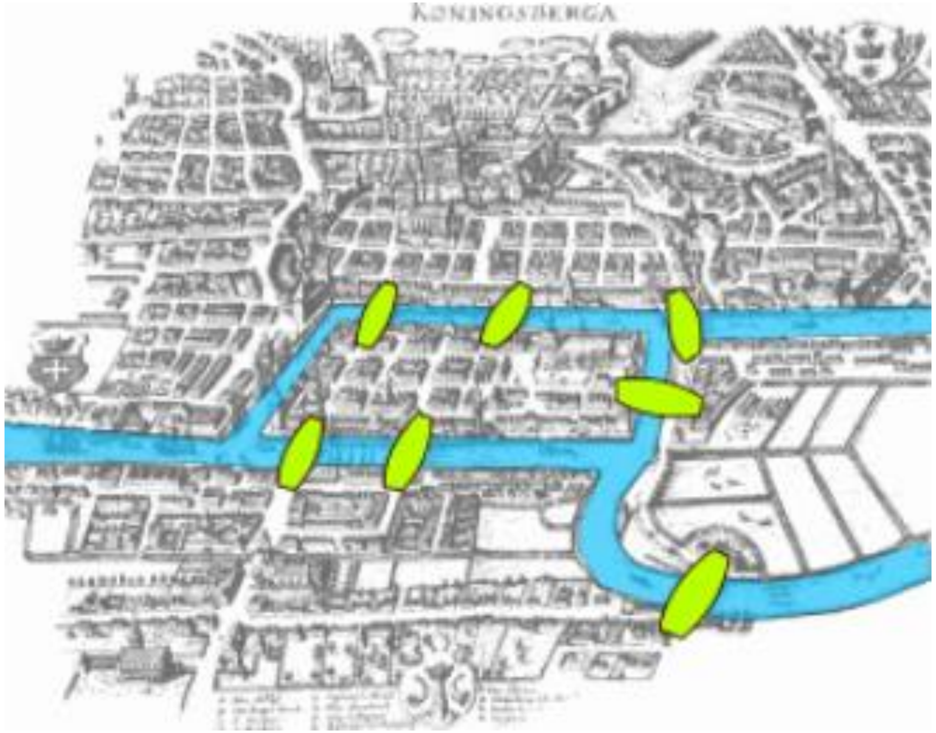
Euler

Homework

- Can you make a Eulerian path around your city?



Euler



Homework

- Can you make a Eulerian path around your city?

Euler

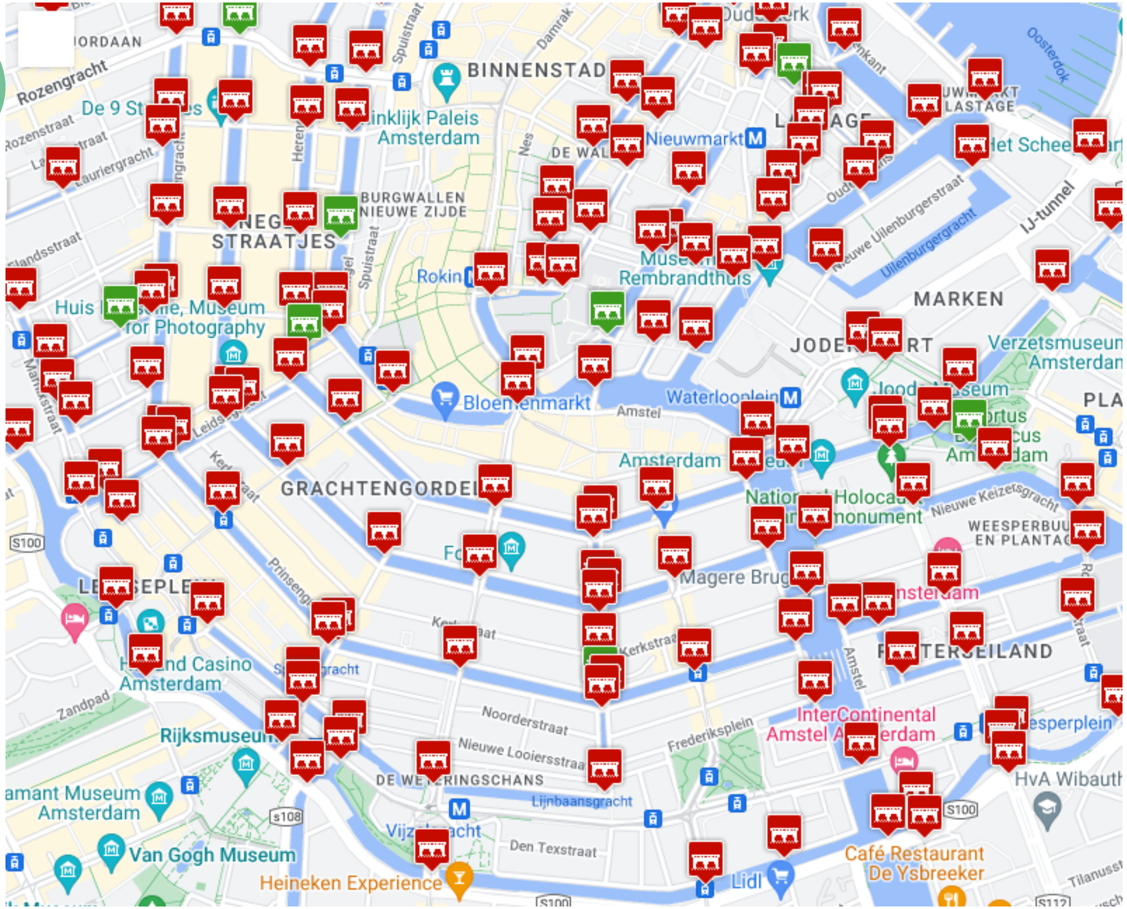
Homework

- Can you make a Eulerian path around your city?

Euler

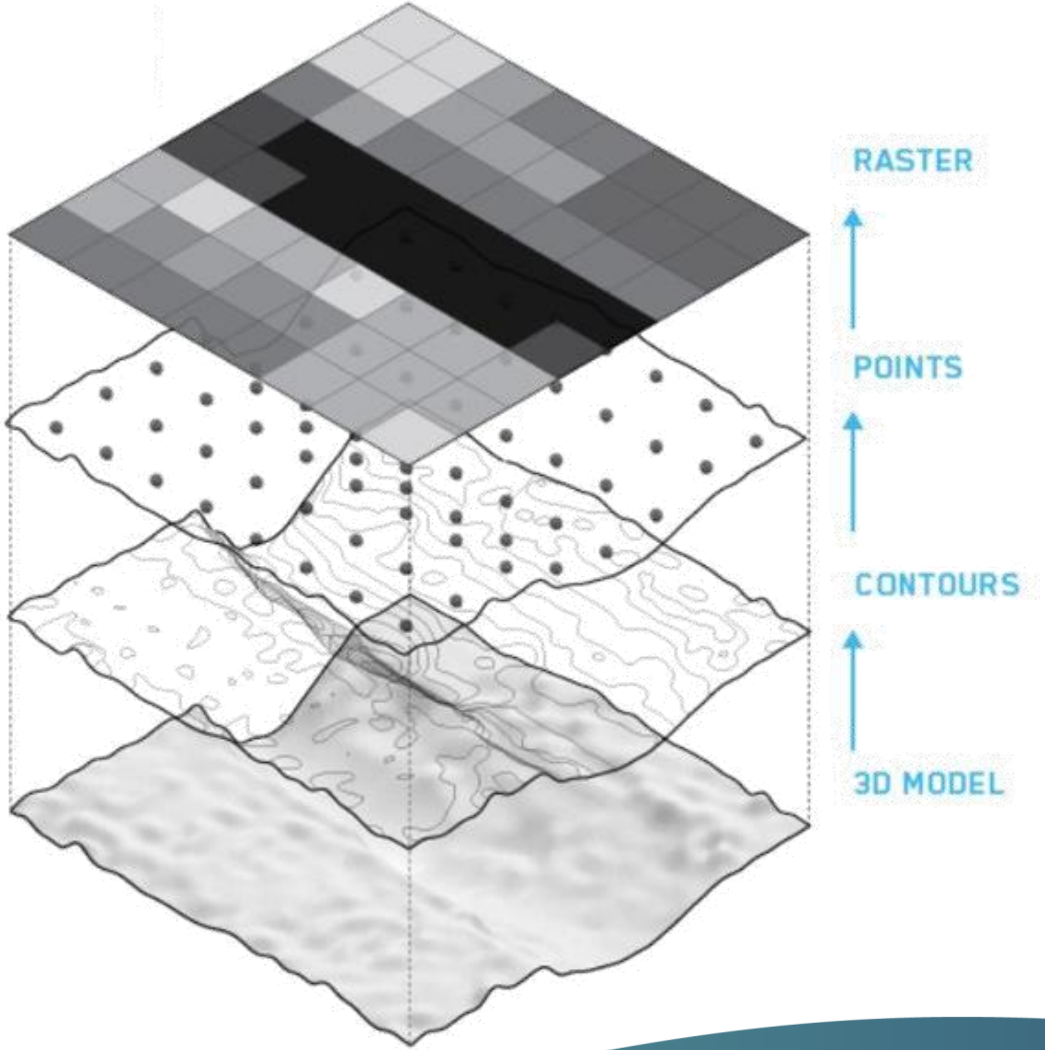
Homework

- Can you make a Eulerian path around your city?



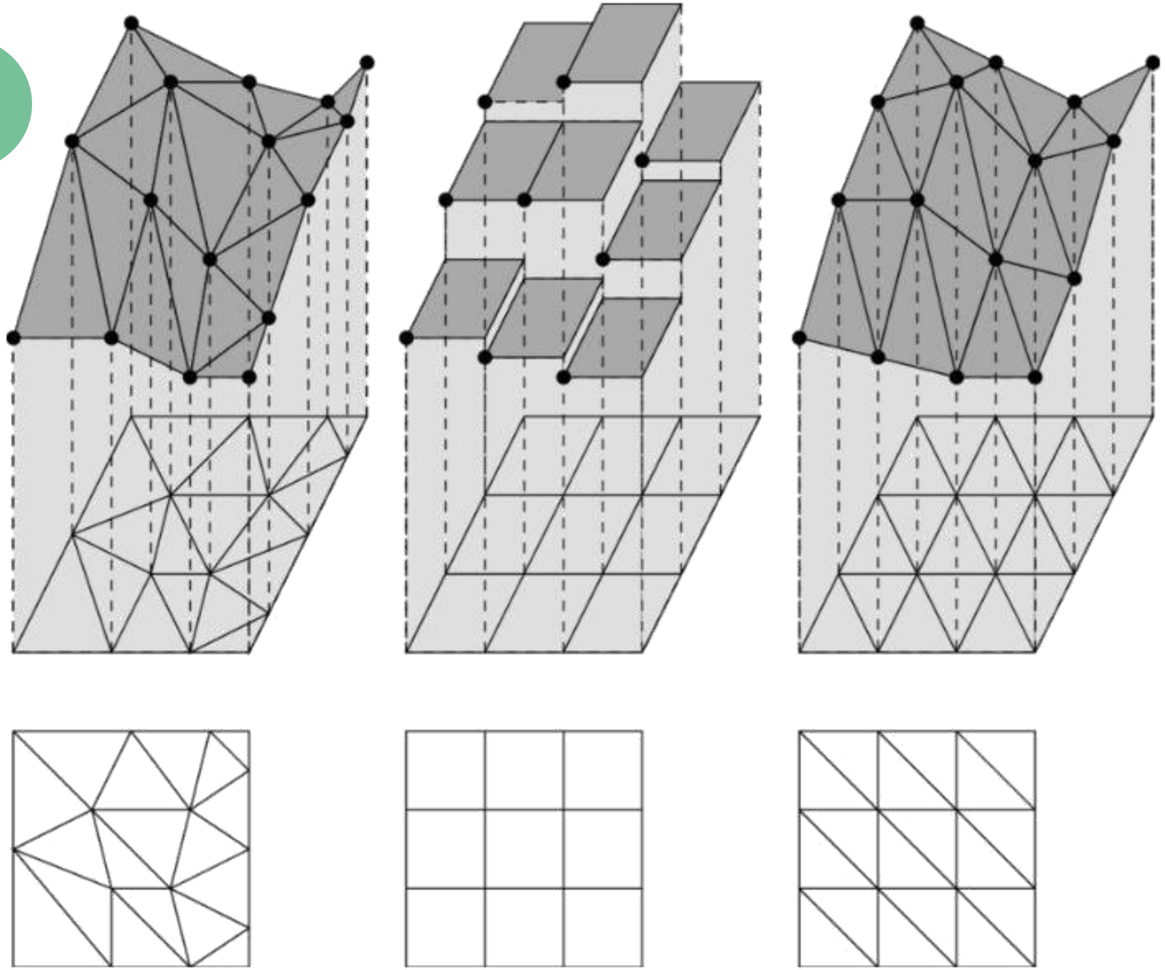
Courant-Friedrichs-Lewy

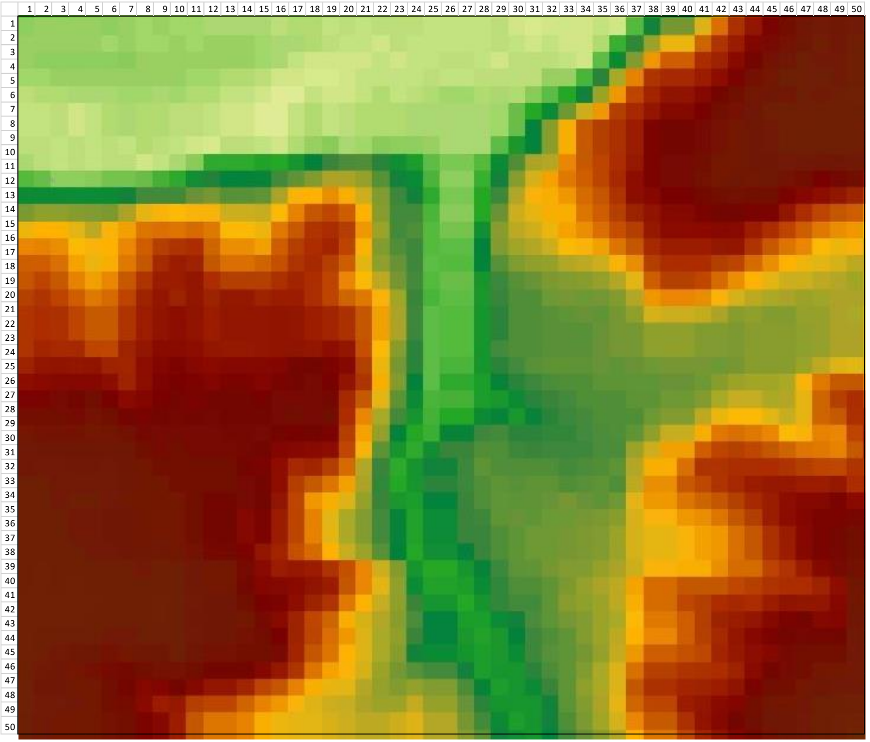
Richard Courant
(1888 – 1972)

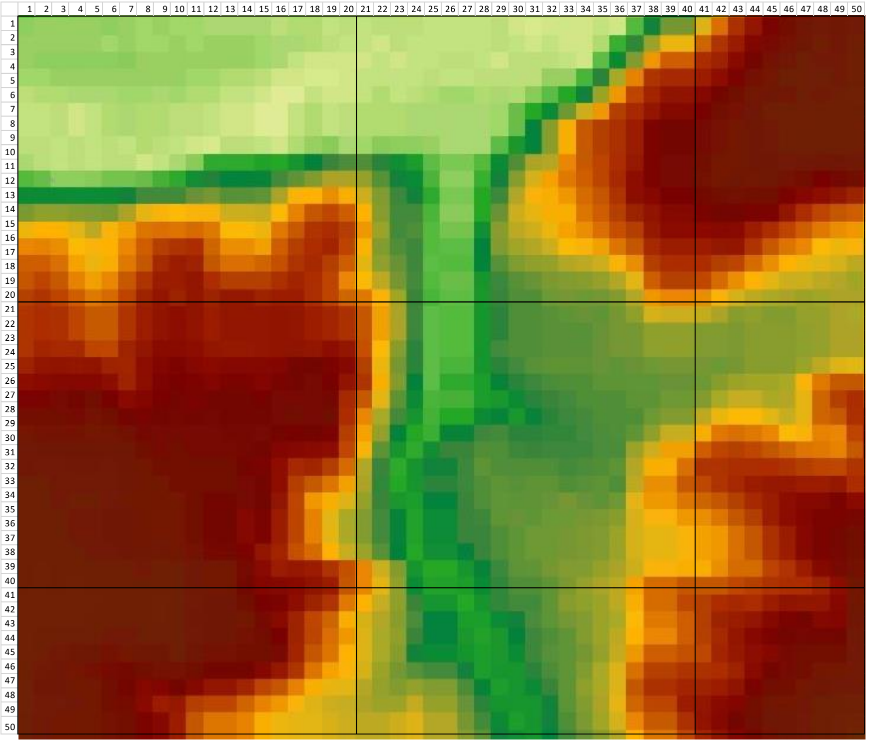


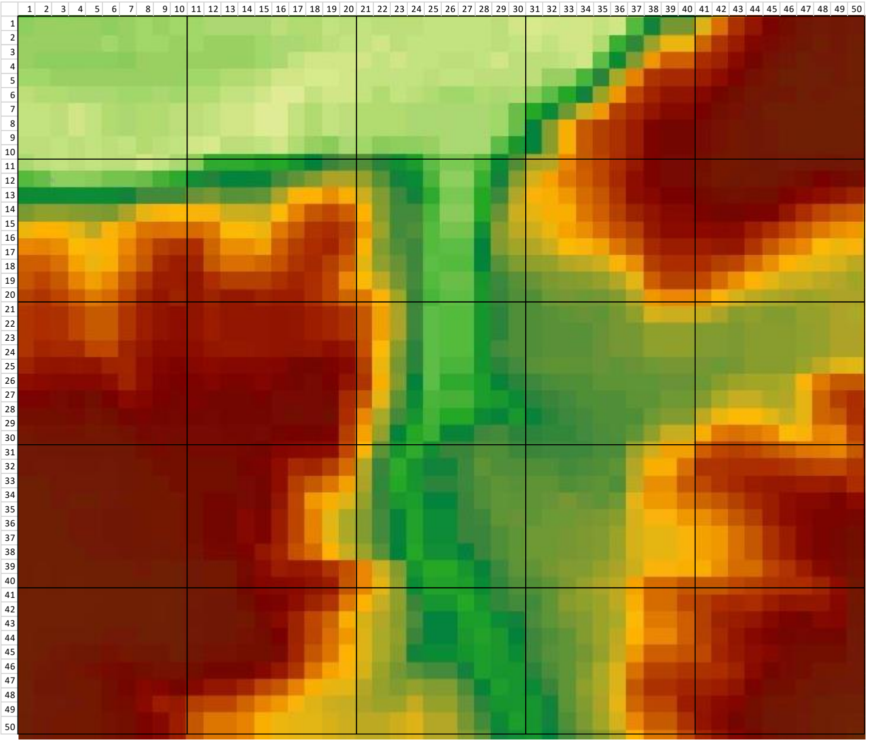
Courant-Friedrichs-Lewy

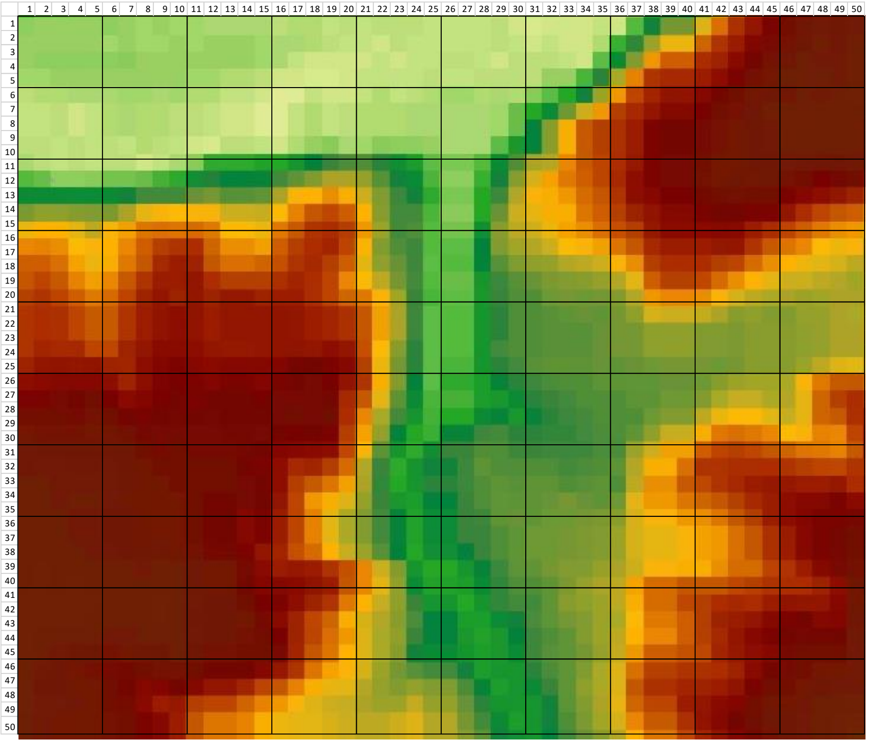
Richard Courant
(1888 – 1972)

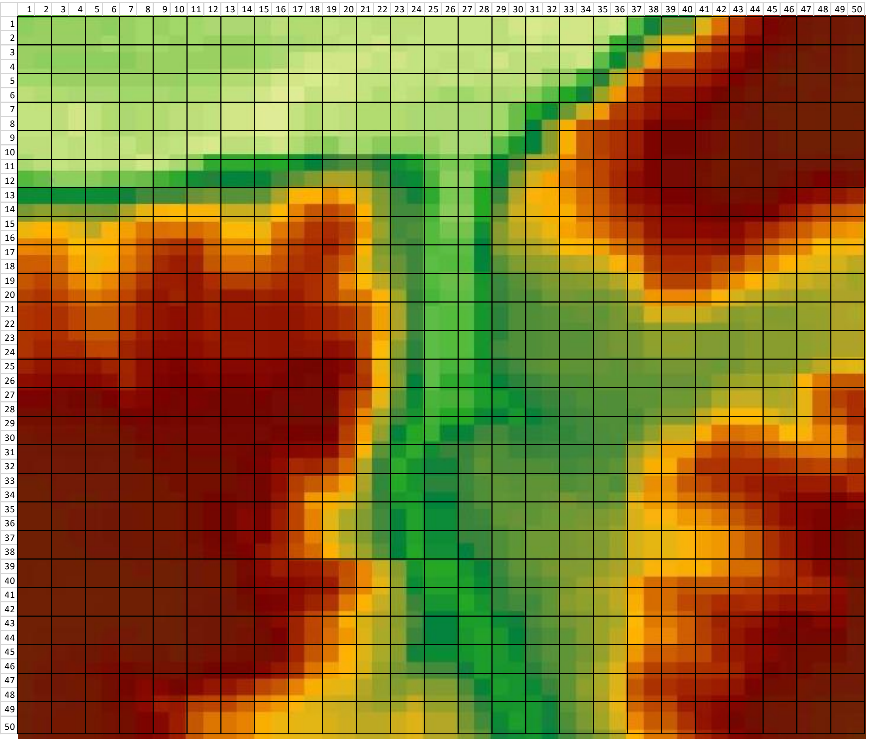


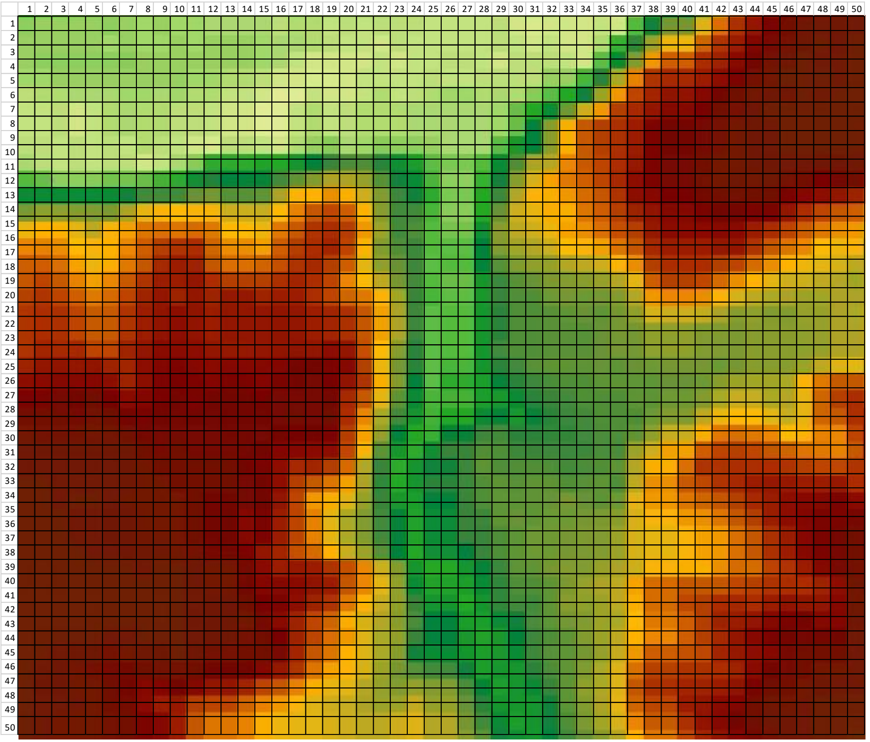

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

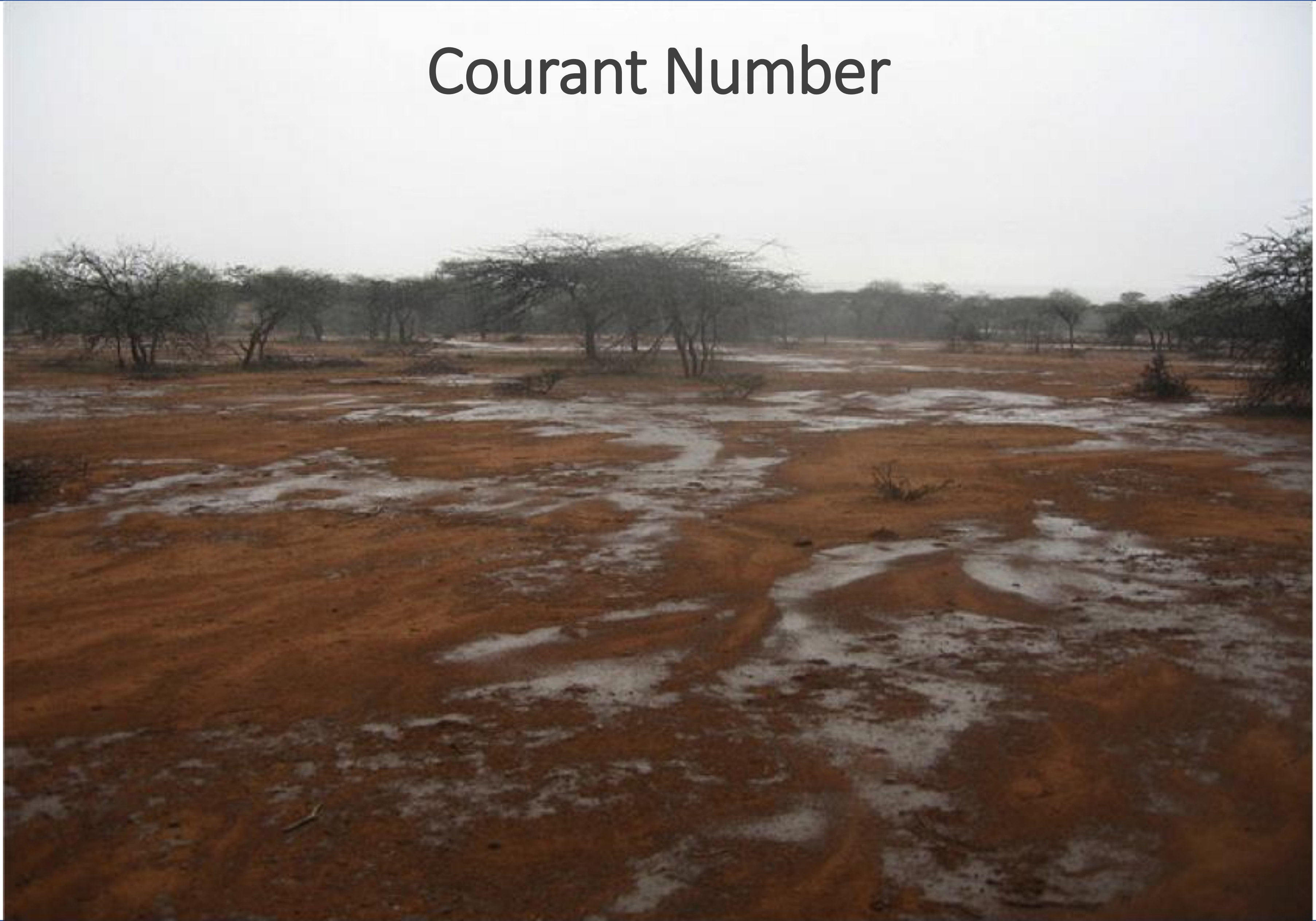



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50



Courant Number



Courant Number
(grid cells per time step)

Courant Number

Courant Number
C=1

Courant Number
C=2

Courant Number
C=3

Courant

NASA/TM—2005-213868

AIAA–2005–4355

Courant Number and Mach Number Insensitive CE/SE Euler Solvers

Sin-Chung Chang
Glenn Research Center, Cleveland, Ohio

$(\nu_{max})_j^n$ can be interpreted as the Courant number at the mesh point (j,n).

Next, for each $m = 1,2,3$, let the points P_m^+ and P_m^-, and the parameter $(\tau_m)_j^n$ shown in Fig. 5 be defined in the exact same manner by which the points P^+ and P^-, and the parameter τ were defined (see Fig. 3). Moreover, let (i) $[\vec{b}]_m$ denote the mth component of any column matrix $\vec{b}$, (ii)

$$\left[(G^{-1})_j^n\vec{u}\right]_m(P_m^+) \stackrel{\text{def}}{=} \left[(G^{-1})_j^n\vec{u}_{j+1/2}^{n-1/2}\right]_m + (\Delta t/2)\left[(G^{-1})_j^n(\vec{u}_t)_{j+1/2}^{n-1/2}\right]_m - \left[1-(\tau_m)_j^n\right]\left[(G^{-1})_j^n(\vec{u}_{\bar{x}})_{j+1/2}^{n-1/2}\right]_m \tag{5.29}$$

and (iii)

$$\left[(G^{-1})_j^n\vec{u}\right]_m(P_m^-) \stackrel{\text{def}}{=} \left[(G^{-1})_j^n\vec{u}_{j-1/2}^{n-1/2}\right]_m + (\Delta t/2)\left[(G^{-1})_j^n(\vec{u}_t)_{j-1/2}^{n-1/2}\right]_m + \left[1-(\tau_m)_j^n\right]\left[(G^{-1})_j^n(\vec{u}_{\bar{x}})_{j-1/2}^{n-1/2}\right]_m \tag{5.30}$$

Note that, in the current development of the procedures for evaluating $(\vec{u}_{\bar{x}})_j^n$, *$(G^{-1})_j^n$ is treated as a fixed constant square matrix for any given fixed $(j,n) \in \Omega$ while $\vec{u}$ is treated as a variable column matrix* (this practice, in spirit, is similar to the definition of $u^*(x,t\,;j,n)$ given in Eq. (2.3) where u_j^n, $(u_x)_j^n$, and $(u_t)_j^n$ are treated as constants while x and t are treated as variables). Thus

$$\frac{\partial\left[(G^{-1})_j^n\vec{u}\right]_m}{\partial t} = \left[(G^{-1})_j^n\frac{\partial\vec{u}}{\partial t}\right]_m \quad \text{and} \quad \frac{\partial\left[(G^{-1})_j^n\vec{u}\right]_m}{\partial\bar{x}} = \left[(G^{-1})_j^n\frac{\partial\vec{u}}{\partial\bar{x}}\right]_m \tag{5.31}$$

It follows that $\left[(G^{-1})_j^n(\vec{u}_t)_{j\pm1/2}^{n-1/2}\right]_m$ and $\left[(G^{-1})_j^n(\vec{u}_{\bar{x}})_{j\pm1/2}^{n-1/2}\right]_m$*, respectively, are the numerical analogues of $\partial\left[(G^{-1})_j^n\vec{u}\right]_m/\partial t$ and $\partial\left[(G^{-1})_j^n\vec{u}\right]_m/\partial\bar{x}$ at the mesh point $(j\pm1/2,n-1/2)$.* With the aid of this interpretation, Eqs. (5.23), (5.29), and (5.30) imply that *$\left[(G^{-1})_j^n\vec{u}\right]_m(P_m^+)$ is a first-order Taylor's approximation of $\left[(G^{-1})_j^n\vec{u}\right]_m$ at point P_m^+ evaluated using the marching variables at the mesh point $(j+1/2,n-1/2)$ while $\left[(G^{-1})_j^n\vec{u}\right]_m(P_m^-)$ is a first-order Taylor's approximation of $\left[(G^{-1})_j^n\vec{u}\right]_m$ at point P_m^- evaluated using the marching variables at the mesh point $(j-1/2,n-1/2)$.* As such, Eqs. (5.29) and (5.30) can be considered as the Euler versions of Eqs. (3.4) and (3.5), respectively. In the following, we will construct the Euler versions of Eqs. (3.6)–(3.9).

By using Eqs. (5.14), (5.21), and (5.23), one has

$$(\Delta t/2)(G^{-1})_j^n(\vec{u}_t)_{j\pm1/2}^{n-1/2} = -(2\Delta t/\Delta x)(G^{-1})_j^n F_{j\pm1/2}^{n-1/2} G_j^n (G^{-1})_j^n(\vec{u}_{\bar{x}})_{j\pm1/2}^{n-1/2} \tag{5.32}$$

Let $F_{j\pm1/2}^{n-1/2} \approx F_j^n$. Then Eqs. (5.12) and (5.26) imply that

$$\frac{\Delta t}{\Delta x}(G^{-1})_j^n F_{j\pm1/2}^{n-1/2} G_j^n \approx \frac{\Delta t}{\Delta x}(G^{-1})_j^n F_j^n G_j^n = diag((\nu_1)_j^n, (\nu_2)_j^n, (\nu_3)_j^n) \tag{5.33}$$

Combining Eqs. (5.32) and (5.33), one has

$$(\Delta t/2)\left[(G^{-1})_j^n(\vec{u}_t)_{j\pm1/2}^{n-1/2}\right]_m \approx -2(\nu_m)_j^n\left[(G^{-1})_j^n(\vec{u}_{\bar{x}})_{j\pm1/2}^{n-1/2}\right]_m \tag{5.34}$$

Substituting Eq. (5.34) into Eqs. (5.29) and (5.30), one arrives at the current Euler versions of Eqs. (3.6) and (3.7), i.e.,

$$\left[(G^{-1})_j^n\vec{u}\right]_m(P_m^+) \approx \left[(G^{-1})_j^n\vec{u}_{j+1/2}^{n-1/2}\right]_m - \left[2(\nu_m)_j^n + 1 - (\tau_m)_j^n\right]\left[(G^{-1})_j^n(\vec{u}_{\bar{x}})_{j+1/2}^{n-1/2}\right]_m \tag{5.35}$$

Get Stoked

$$
\begin{aligned}
r:\quad & \rho\left(\frac{\partial u_r}{\partial t}+u_r\frac{\partial u_r}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_r}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_r}{\partial \theta}-\frac{u_\phi^2+u_\theta^2}{r}\right)=-\frac{\partial p}{\partial r}+\rho g_r+\\
& \mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_r}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_r}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_r}{\partial \theta}\right)-2\frac{u_r+\frac{\partial u_\theta}{\partial \theta}+u_\theta\cot(\theta)}{r^2}-\frac{2}{r^2\sin(\theta)}\frac{\partial u_\phi}{\partial \phi}\right]\\
\phi:\quad & \rho\left(\frac{\partial u_\phi}{\partial t}+u_r\frac{\partial u_\phi}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_\phi}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_\phi}{\partial \theta}+\frac{u_r u_\phi+u_\phi u_\theta\cot(\theta)}{r}\right)=-\frac{1}{r\sin(\theta)}\frac{\partial p}{\partial \phi}+\rho g_\phi+\\
& \mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_\phi}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_\phi}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_\phi}{\partial \theta}\right)+\frac{2\sin(\theta)\frac{\partial u_r}{\partial \phi}+2\cos(\theta)\frac{\partial u_\theta}{\partial \phi}-u_\phi}{r^2\sin(\theta)^2}\right]\\
\theta:\quad & \rho\left(\frac{\partial u_\theta}{\partial t}+u_r\frac{\partial u_\theta}{\partial r}+\frac{u_\phi}{r\sin(\theta)}\frac{\partial u_\theta}{\partial \phi}+\frac{u_\theta}{r}\frac{\partial u_\theta}{\partial \theta}+\frac{u_r u_\theta-u_\phi^2\cot(\theta)}{r}\right)=-\frac{1}{r}\frac{\partial p}{\partial \theta}+\rho g_\theta+\\
& \mu\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial u_\theta}{\partial r}\right)+\frac{1}{r^2\sin(\theta)^2}\frac{\partial^2 u_\theta}{\partial \phi^2}+\frac{1}{r^2\sin(\theta)}\frac{\partial}{\partial \theta}\left(\sin(\theta)\frac{\partial u_\theta}{\partial \theta}\right)+\frac{2}{r^2}\frac{\partial u_r}{\partial \theta}-\frac{u_\theta+2\cos(\theta)\frac{\partial u_\phi}{\partial \phi}}{r^2\sin(\theta)^2}\right].
\end{aligned}
$$

Courant

$$C_r = \left[\frac{(u + \sqrt{gd}) \,.\, \Delta t}{\Delta x} \right]$$

Courant

$$C = \frac{V \Delta T}{\Delta X} \leq 1.0$$

DERT

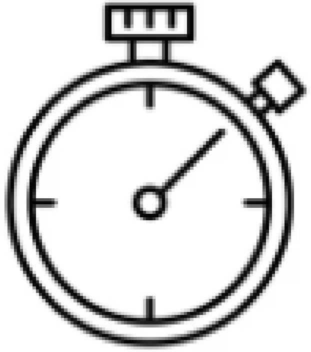
Thanks for Attending

DIRT

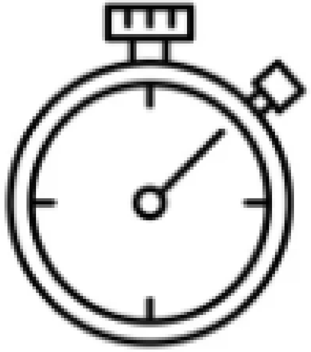
D=RT

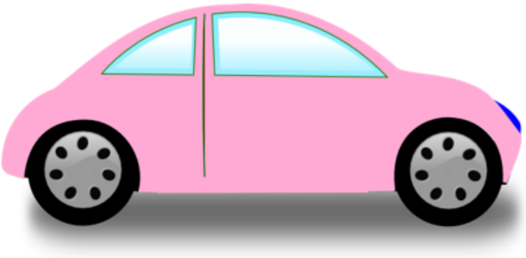
Thanks for Attending

D=RT



D=RT





85.8 km

Thanks for Attending

X =RT

Thanks for Attending

$$X = VT$$

Australian Water School

Thanks for Attending

$\underline{X} = VT$

Thanks for Attending

$$\frac{X}{V} = T$$

Thanks for Attending

$$T = \frac{X}{V}$$

Australian Water School

Thanks for Attending

$$T = \frac{X}{V}$$

Thanks for Attending

$$V = \frac{X}{T} \quad T = \frac{X}{V} \quad X = VT$$

Courant

HPC 2D Adaptive Timestep Controlling Numbers			
Control Number	**Description**	**Expression**	**Control Number Limit**
Courant Number (Nu)	This condition ensures that water entering one side of a 2D cell does not pass through the other side within one timestep. For this to be satisfied, the product of the water velocity (u) and model timestep (Δt) must be less than the cell size (Δx).	$N_u = \max\left(\frac{\lvert u\rvert\Delta t}{\Delta x}, \frac{\lvert v\rvert\Delta t}{\Delta y}\right) \leq 1.0$	<1.0
The Shallow Wave Celerity Number (Nc)	This numerical condition relates to the shallow water wave celerity (wave speed) and is derived from the fluid flow equations to represent long waves (i.e. wave length is substantially longer than the water depth). The product of the model timestep (Δt) and the long wave speed (square root of the gravity (g) and water depth (h)) must be less than the cell size (Δx), for the condition to be satisfied.	$N_c = \max\left(\frac{\sqrt{gh}\Delta t}{\Delta x}, \frac{\sqrt{gh}\Delta t}{\Delta y}\right) \leq 1.0$	<1.0
Diffusion Number (Nd)	This numerical condition relates to the sub-grid scale eddy viscosity term which causes diffusion of momentum. To maintain stability the product of the eddy viscosity coefficient (v_T) and the timestep (Δt) divided by the square of the grid spacing ($\Delta x2$) must remain below 0.3. Models controlled by the diffusion number tend to require a timestep significantly smaller than those controlled by the shallow wave celerity or courant numbers. If you find your model is predominantly diffusion controlled it may be that equivalent solution accuracy can be achieved by selecting a larger cell size. This is worth testing, as it will most likely increase the simulation speed with no loss of result fidelity.	$N_d = \max\left(\frac{\nu_T\Delta t}{\Delta x^2}, \frac{\nu_T\Delta t}{\Delta y^2}\right) \leq 0.3$	<0.3

- The `Timestep` command included in the TUFLOW Control File (TCF) is only used for the first calculation timestep. The specified value should be consistent with what would be appropriate for a TUFLOW Classic model (i.e. 1/2 to 1/5 the 2D cell size). Internally, TUFLOW HPC divides this value by 10 to apply a value that is suitable for an explicit solution scheme. All subsequent calculations are completed using the adaptive timestep approach outlined in the following bullet points.

$$\text{Time Step (s)} = \frac{1}{2} \text{ Grid Size (m)}$$

Courant

HPC 2D Adaptive Timestep Controlling Numbers			
Control Number	**Description**	**Expression**	**Control Number Limit**
Courant Number (Nu)	This condition ensures that water entering one side of a 2D cell does not pass through the other side within one timestep. For this to be satisfied, the product of the water velocity (u) and model timestep (Δt) must be less than the cell size (Δx).	$N_u = \max\left(\frac{\lvert u\rvert \Delta t}{\Delta x}, \frac{\lvert v\rvert \Delta t}{\Delta y}\right) \leq 1.0$	<1.0
The Shallow Wave Celerity Number (Nc)	This numerical condition relates to the shallow water wave celerity (wave speed) and is derived from the fluid flow equations to represent long waves (i.e. wave length is substantially longer than the water depth). The product of the model timestep (Δt) and the long wave speed (square root of the gravity (g) and water depth (h)) must be less than the cell size (Δx), for the condition to be satisfied.	$N_c = \max\left(\frac{\sqrt{gh}\Delta t}{\Delta x}, \frac{\sqrt{gh}\Delta t}{\Delta y}\right) \leq 1.0$	<1.0
Diffusion Number (Nd)	This numerical condition relates to the sub-grid scale eddy viscosity term which causes diffusion of momentum. To maintain stability the product of the eddy viscosity coefficient (v_T) and the timestep (Δt) divided by the square of the grid spacing (Δx2) must remain below 0.3. Models controlled by the diffusion number tend to require a timestep significantly smaller than those controlled by the shallow wave celerity or courant numbers. If you find your model is predominantly diffusion controlled it may be that equivalent solution accuracy can be achieved by selecting a larger cell size. This is worth testing, as it will most likely increase the simulation speed with no loss of result fidelity.	$N_d = \max\left(\frac{\nu_T \Delta t}{\Delta x^2}, \frac{\nu_T \Delta t}{\Delta y^2}\right) \leq 0.3$	<0.3

- The `Timestep` command included in the TUFLOW Control File (TCF) is only used for the first calculation timestep. The specified value should be consistent with what would be appropriate for a TUFLOW Classic model (i.e. 1/2 to 1/5 the 2D cell size). Internally, TUFLOW HPC divides this value by 10 to apply a value that is suitable for an explicit solution scheme. All subsequent calculations are completed using the adaptive timestep approach outlined in the following bullet points.

$$\text{Time Step (s)} = \frac{1}{2} \text{ Grid Size (m)}$$

Assumed V=2 m/s for C=1

Courant

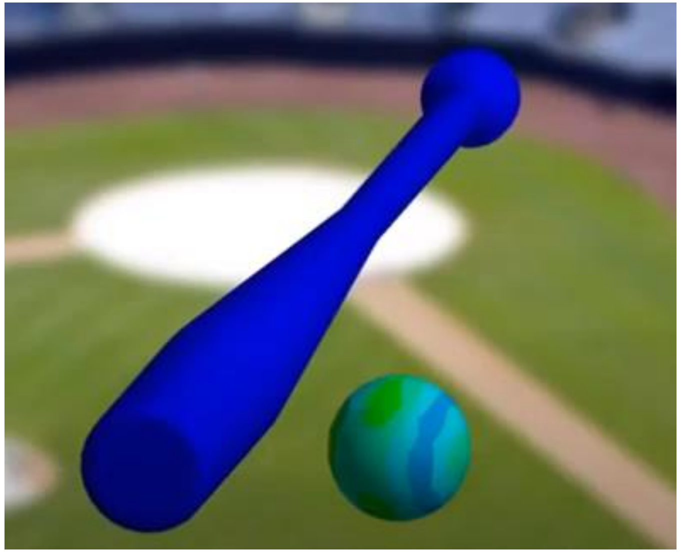
HPC 2D Adaptive Timestep Controlling Numbers			
Control Number	**Description**	**Expression**	**Control Number Limit**
Courant Number (Nu)	This condition ensures that water entering one side of a 2D cell does not pass through the other side within one timestep. For this to be satisfied, the product of the water velocity (u) and model timestep (Δt) must be less than the cell size (Δx).	$N_u = \max\left(\frac{\lvert u\rvert \Delta t}{\Delta x}, \frac{\lvert v\rvert \Delta t}{\Delta y}\right) \leq 1.0$	<1.0
The Shallow Wave Celerity Number (Nc)	This numerical condition relates to the shallow water wave celerity (wave speed) and is derived from the fluid flow equations to represent long waves (i.e. wave length is substantially longer than the water depth). The product of the model timestep (Δt) and the long wave speed (square root of the gravity (g) and water depth (h)) must be less than the cell size (Δx), for the condition to be satisfied.	$N_c = \max\left(\frac{\sqrt{gh}\Delta t}{\Delta x}, \frac{\sqrt{gh}\Delta t}{\Delta y}\right) \leq 1.0$	<1.0
Diffusion Number (Nd)	This numerical condition relates to the sub-grid scale eddy viscosity term which causes diffusion of momentum. To maintain stability the product of the eddy viscosity coefficient (v_T) and the timestep (Δt) divided by the square of the grid spacing (Δx2) must remain below 0.3. Models controlled by the diffusion number tend to require a timestep significantly smaller than those controlled by the shallow wave celerity or courant numbers. If you find your model is predominantly diffusion controlled it may be that equivalent solution accuracy can be achieved by selecting a larger cell size. This is worth testing, as it will most likely increase the simulation speed with no loss of result fidelity.	$N_d = \max\left(\frac{\nu_T \Delta t}{\Delta x^2}, \frac{\nu_T \Delta t}{\Delta y^2}\right) \leq 0.3$	<0.3

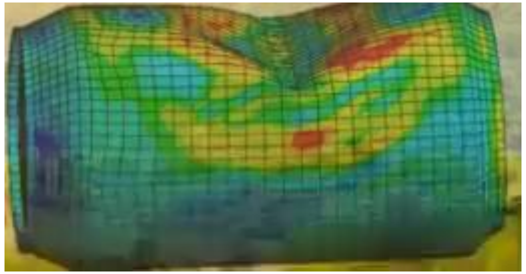
- The `Timestep` command included in the TUFLOW Control File (TCF) is only used for the first calculation timestep. The specified value should be consistent with what would be appropriate for a TUFLOW Classic model (i.e. 1/2 to 1/5 the 2D cell size). Internally, TUFLOW HPC divides this value by 10 to apply a value that is suitable for an explicit solution scheme. All subsequent calculations are completed using the adaptive timestep approach outlined in the following bullet points.

$$\text{Time Step (s)} = \frac{1}{5} \text{ Grid Size (m)}$$

Assumed V=5 m/s for C=1

Courant





$$\text{Time Step (s)} = \frac{1}{5}\ \text{Grid Size (m)}$$

Assumed V=5 m/s for C=1

Laws and Equations

- Darcy
- Bernoulli
- Reynolds
- Mannings
- Navier-Stokes
- Saint Venant
- Shields

Laws and Equations

- Darcy
- Bernoulli
- Reynolds
- Mannings
- Navier-Stokes
- Saint Venant
- Shields
- Permeability
- Pressure
- Head Loss
- Friction
- Turbulence
- Viscosity
- Shear

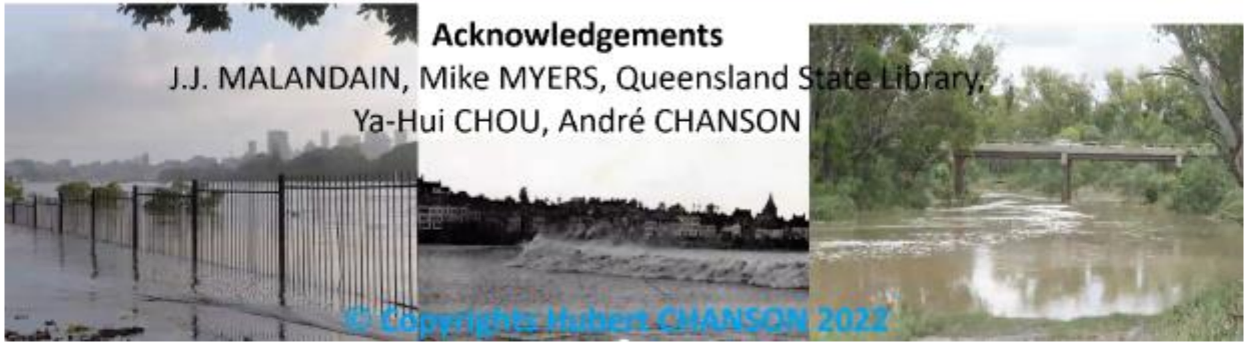
Dr. Chanson

Saint-Venant equations & the simplification of the dynamic equation

by Hubert CHANSON
ssor, School of Civil Engineering, The University of Queensland, Brisbane QLD 4072, Australia, E-mail: h.chanson@uq.edu.au
{http://espace.library.uq.edu.au/list/author_id/193/}

Hubert Chanson YouTube channel
ttps://www.youtube.com/channel/UCm-SedWAjKdQdGWNbCwppqw}

Acknowledgements
J.J. MALANDAIN, Mike MYERS, Queensland State Library,
Ya-Hui CHOU, André CHANSON



Dr. Chanson