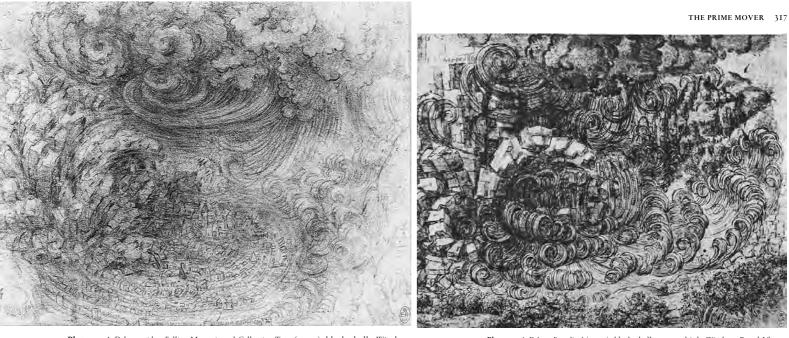
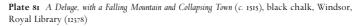
Leonardo and the motion of fluids (water, air and blood)

Uriel Frisch Laboratoire Joseph-Louis Lagrange UCA, OCA, CNRS, Nice, France 316 THE PRIME MOVER





THE REPUBLIC: NEW BATTLES AND OLD PROBLEMS 255

Plate 82 A Deluge, Formalized (c. 1515), black chalk, pen and ink, Windsor, Royal Library (12380)



Long and attache estavite estavite estave and estave estave and a provisive and estave estimates and estave estave e a thank attende attende versite frank in an attende in the stand of the standard attended a

WITCHN' GOADING

afar sina aller anon tela

ס שראמים העור ברלעון ומוב ליילם המצר להקות למים להקומה כון כל שחיר שונו והוביציים המצוע להדיל שלוואימה ב אבל ווג הוצים לושון כל להכון הביוקר היו היוסי כבולותיו ה כבי עד כון לולו מעורה ביוקר להכואה הואידיו להכועה המצירה לישום. כבולותיו ה כבי ווה הלאמיניה היה להכול כלוה ביציר הבולותיומים החומבלה לביווחייה לי אום המוכו ולוואיל לבולולה מערילותים כמולותיום לפולב קוביליוני יצילים להרומן.

Plate 80 Studies of Hydrodynamic Turbulence (c. 1508–9), pen and ink, Windsor, Royal Library (12660V)

Plate 66 Composite Study of the Respiratory, Vascular and Urino-genital Systems in (c. 1508), black chalk, pen and ink and wash, Windsor, Royal Library (12281)

THE REPUBLIC: NEW BATTLES AND OLD PROBLEMS 253

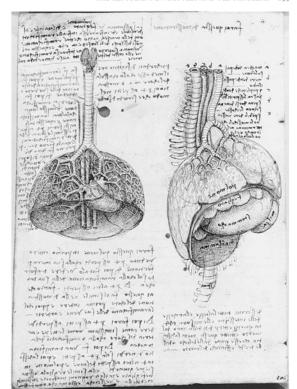


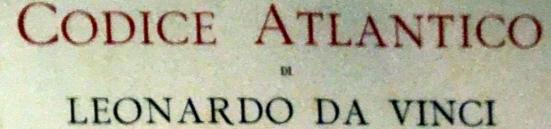
Plate 65 The Trachea and Bronchii Studied in Isolation and a Study of Thoracic and Abdominal On (c. 1508), black chalk, pen and ink, Windsor, Royal Library (19054v)

- mis tobelle agaque follocome fonte por gella e tentro affre polagio fone the petre de carquela fone aguigne demarte des quet quarte deffisionerges infie explanger coquetto elle enute efficile chi fare n'fimite 1/22 finquello sella nria fomería el 2° equel definio elle neque refrelle porta. (na pertuin (ninpre muran aria alalun ania (aquate por cienale neque ell'una infigura a gralli tan portune l'ampre mutant arte allatta auta l'aque le poi d'ettate aque el une infrance alla pelle siperagie pollare acquipe pois ufallaria c'aquellarica e nella fupfini ellocano penetrato y la infine alfo tallacque eleritorna infrieto allacio ella fue ciaque elar toto filo puto nella pelle siperagie tallacque eleritorna infrieto allacio ella fue ciaque elarito filo qui to moto ribellato in infinita negli ellacque represta di quantale riporte fario elevato i formerfo alla fu e el ilquele ellaque della lacque represta di aquesta riporte fario elevato i formerfo alla fu

marfin filaqua

Son Conners & Engine vapren 6 on silfirona infralaria dat the action none ofference fete it w na fifting angele protectionente volar Competicie protectione (oralise effectione scores and the second statistics) Obefuto nelle por aftione felle nobe lacque for lacque offerbore pin integral mente lare notive per la comparting de lacque offerbore pin integral constituto nature per la comparting de lacque de la compartina contra compartina infrallava plaque de compartina de defiemede infrala come immodife tanto atripatione quito da potente tella model a compartine to no moder infrallavia piño da potente tella potente antegla compartine to no moder infrala (etilita metrica confirma de delle portette re de latora)

Codex Atlanticus (Biblioteca Ambrosiana, Milano)



IL

NELLA BIBLIOTECA AMBROSIANA

DI MILANO

RIPRODOTTO E PUBBLICATO

REGIA ACCADEMIA DEI LINCEI

NOTTO OLI AUGRIZI & COL MUSSIONI

DEL RE E DEL GOVERNO

TRAFERINGRE DIVLORATION CRITICS

TESTO I



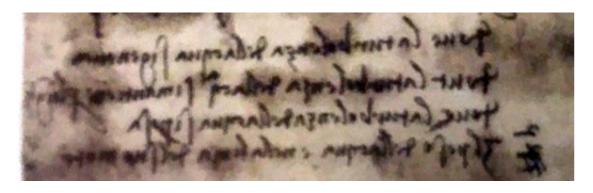


Verified auror Nexe C20200CAB33464.3006655480C154E2 free do. Perte Verchio - Wikipedia Perte Verchio - Wikipedia Perte Verchio - Wikipedia Perte Verchio - Wikipedia

1478 - 1519 In Folio 12 volumes 1119 sheets Hoepli 1894-1904 Academia dei Lincei

DESEGNI DI MACHINE ET DELLE ARTI SECRETI ET ALTRE COSE DEI DI LEONARDO DA VINCI RACCOLTA DA POMPEO LEO

Turbulence along the river Arno



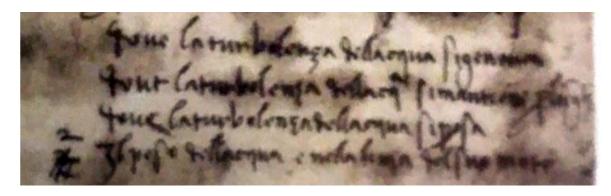
In English

where the turbulence of water is generated where the turbulence of water maintains for long where the turbulence of water comes to rest

Modern phenomenological approach

Low Reynold number: $R = LV/\nu \ll 1$

$$\frac{dU}{dt} = -\frac{\nu}{L^2}U$$
$$U(t) = U(0) e^{-\frac{\nu}{L^2}t}$$

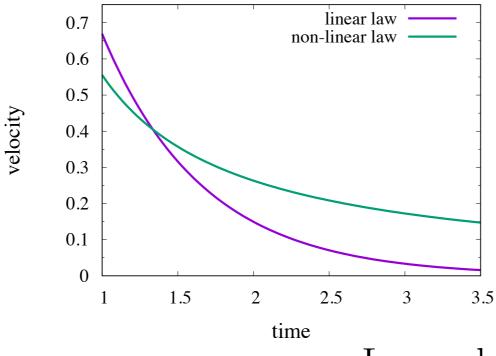


In modern italian

dove la turbolenza dell'acqua si genera dove la turbolenza dell'acqua si mantiene per lungo dove la turbolenza dell'acqua si posa

> Phenomenological approach (Kármán 1938) High Reynolds number: $R = LV/\nu \gg 1$

$$\frac{dU}{dt} = -\frac{U}{L/U}$$
$$U(t) = \frac{L}{t - t_0}$$



Leonardo and the word "turbulence"...

"Turbulence". Leonardo and latin. "Omo sanza lettere". Leonardo, mathematics and hydrodynamics.

- Where did Leonardo find the word "turbulence"? In Latin ? Probably not.
- Leonardo liked to define himself as a man without literature (*Omo sanza lettere*), that is a man without Latin.
- In the middle ages, in vulgar latin, that is the common speech used in France and Italy, *turbulent* designated the trouble makers. Stemming of course from the Latin *turba*, the disordered motion of a crowd.
- Although Leonardo understood very little Latin, he had a real passion for mathematics.
 His notebooks make this clear from the beginning: "Who is not a mathematician should not read the elements of my work."
- At the time of Leonardo mathematics included mostly geometry and algebra. Leonardo preferred geometry naturally associated with his brush. According to Martin Kempf "Leonardo da Vinci. The Marvellous Works of Nature and Man" (2006), here is how Leonardo imagined the motions shown above (this text is mostly a translation of Leonardo's own).
 - Running water has within itself an infinite number of movements which are greater or lesser than its principal course. This is proved by [watching] the things supported within two streams of water which are the same weight as the water.' The revealed motions of such things were 'sometimes swift, sometimes slow, and sometimes turning to the right and sometimes to the left, at one instant upwards and at another downwards, turning over and back on itself, now in one direction and now in another, obeying all the forces that have power to move it, and in the struggles perpetrated by the mobile forces always as the booty of the victor'