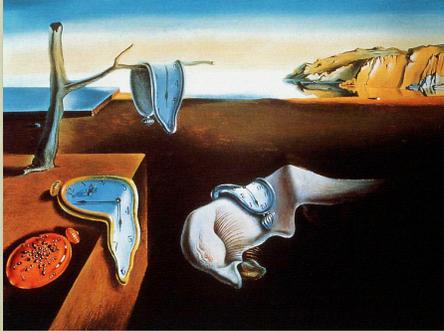


Aspects of Time

Peter Watson



What then is time?

- *If no one asks me, I know what it is. If I wish to explain it to him who asks, I do not know.*
- **St Augustine**
- **Time is what we don't have enough of.**

I do not define time, space, place, and motion, as being well known to all.

Isaac Newton

Shut up and calculate!

Statutory Warning

- This is an experimental course
- You are guinea pigs

- Who are you?
- Peter Watson
- How do I find you?
 - Best: mail to watson@physics.carleton.ca and put something sensible in the subject line
 - HP 3318 520-2600 x4318
 - Office Hours: 9.30-11.00 Tuesdays specifically. Most other times, but send me an Email to make sure I am there.
 - www.physics.carleton.ca/~watson
 - Note: all course information is posted here

What do you already know about time?

- What time is it?

What do you already know about time?

- How old is ?

What do you already know about time?

- How old am I ?

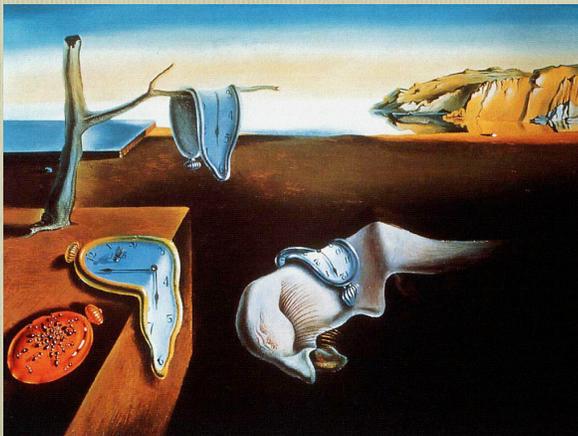


Roughly, we have

- Physical Time
- Psychological Time *Are they the same?*
- Biological Time *Or are they different aspects of the same thing?*
- Sociological Time
- Astronomical Time
- Historical Time
- Geological Time



- What's the picture?



9

What does a clock measure?

- What does "prediction" mean?
- When did time measurement start?
- Do we experience time in the same way?
- Why does time pass quicker as we get old?
- What defines the direction of time?
- Physiological Time: what is a biological clock?
- How short a time can we perceive?
- What exactly is causality?
- Is time travel possible?
- If so, why can't we do it?
- If not, what forbids it?
- How do we know that two clocks measure the same time?
- How are time and space linked?
- Is time "smooth"?
- Did time begin?
- Will it end?



Where are we going?

1. Time and Language: How we talk about time
2. Chronos and Kairos: Literature and Time
3. Wait a second: How we Perceive time.
4. Stonehenge to Caesium: How we Measure Time
5. Biological clocks
6. Time and Philosophy.
7. Bicycle Pumps and Rice Puddings: Time's Arrow
8. Going Straight in a Bent Space: How Matter bends Time
9. Grouse, Hurricanes and Dead Cats: How to predict
10. Deep Time: How Geology changed time
11. The Beginning and the End.



Time and Language:

- How we talk about time. Most Western languages have a very sophisticated description of time. This is based on a simple mental model of time, (the linear model) which we will see later on is inadequate. It is not surprising that some primitive languages cannot discuss temporal concepts, but it is surprising that there are concepts that cannot be described in English.

- [Peter Watson \(2 lectures\)](#)



Chronos and Kairos: Time and Literature

- Classic literature shows an increasing sophistication in our understanding of time. We start with the Greeks and go to the present day
- Adam Burrows (2 lectures)



Peter Watson

Stonehenge to Caesium: How we Measure Time

- The oldest measurements of time date back at least 10000 years. A crude understanding of the seasons is essential for farming, so agricultural communities were the first to develop calendars.
- The more sophisticated our measurements became, the more difficult it becomes to reconcile solar, sidereal, lunar and terrestrial timekeeping. Our ability to measure time with increasing accuracy inevitably leads to the question of whether time is infinitely divisible, or whether there are "bits" of time.
- Evaluation: essay comparing an ancient calendar (e.g. Babylonian, Egyptian, Mayan, Chinese) with the modern calendar, or comparing early measurement of time with current methods
- Peter Watson 2 lectures



Peter Watson

Biological Clocks

We have various biological clocks: some diurnal (we feel sleepy at night), some related to our life-span (we mature and grow old). What drives them?

- Caleb Hasler (2 lectures)



Peter Watson

Wait a second: How we Perceive time

- Memory and time are intimately linked, which is possibly why our perception of time changes as we age.
- How do we estimate time?
- Evaluation: students would be asked to test each other to find out how good time estimates actually are.
- Craig Leth-Steensen (1 lecture)



Peter Watson

Time and Philosophy.

- Some leading philosophical questions about time are:
- What is time? Can the notion be defined?
- Is time real or is it a perceptual illusion?
- Given that only the present moment exists (the past no longer exists and the future does not yet exist), could there be an alternative universe whose 'now' is five minutes before ours?
- We can change things in all dimensions of space; why with time can we change things only in the future?

- Andrew Brook (2 lectures)



Peter Watson

Bicycle Pumps and Rice Puddings: Time's Arrow

- The question of how tomorrow differs from yesterday is trite in terms of the human experience, but it is surprisingly hard to define in physics terms.
- We have to introduce the concept of entropy, which arises from 19th century thermodynamics
- Peter Watson: 2 lectures



Peter Watson

Deep Time.

- One of the most profound scientific debates of the 19th century was the discussion of our planet's age. Observations by geologists of the time opened our eyes to the immense time-scales involved.
- [Allan Donaldson 2 lectures](#)



Going Straight in a Bent Space: How Matter bends Time

- The ideas behind Special and General Relativity, formulated by Einstein at the start of the 20th century, undermine most of our intuition.
- Not only is the concept of universal time no longer possible but words as simple as “simultaneous” lose their meaning. Perhaps worst of all, it is possible to construct universes mathematically in which time travel is possible.
- Evaluation: an assignment constructing space-time diagrams for some simple situations.
- [Peter Watson: 4 lectures](#)



Grouse, Hurricanes and Dead Cats: How to predict

- Even if actual time travel is impossible, perhaps we can virtually time-travel by predicting the future. It is possible to prove that there are systems which are intrinsically unpredictable, so forecasting must always be imprecise
- [Peter Watson \(2 lectures\)](#)



The Beginning and the End.. Did Time begin? Will it end?

- Most astronomers believe that the universe began in the Big Bang, about 4 billion years ago. What consequences does this have for the start of time?
- Can we say anything about the end of time?
- [Peter Watson \(2 lectures\)](#)



Summary

We will try to pull together many of the ideas of the course and present our current understanding and the still unanswered questions

- Evaluation: essay comparing two (or more) cultural works on time
- [Peter Watson \(2 lectures\)](#)



Time and Culture

Note we will be using “culture” generically

- Literature
- Theatre
- Film
- TV
- Music
- Art



Sources:

Books (non-fiction):

**Time Machines (Paul J. Nahin, also with K. S. Thorne)
Time Travel in Einstein's Universe (J. Richard Gott)
In Search of Time: The History, Physics, and Philosophy of Time (Dan Falk)
About Time (Paul Davies)
** Physics of Star Trek (Lawrence Krauss)
** An Experiment with Time (J. W. Dunne)
** The Labyrinth of Time (Michael Lockwood)
** The End of Time (Julian Barbour)
** From eternity to here: the quest for the ultimate theory of time (Sean Carroll)
**Time, space, and metaphysics (Bede Rundle).
**Time & the instant: essays in the physics and philosophy of time (edited by Robin Durie)
** Psychology of Time (Edited Simon Grenadine)
Physics of Star Trek (L. Krauss)
The Physics of the Buffyverse (J. Ouellette)
** The Stuff of Thought : Language as a Window into Human Nature (Steven Pinker)
** Don't Sleep, There are Snakes (Daniel Everett)



Fiction: short stories

All You Zombies..... (Robert Heinlein)

...and he built a Crooked House (Robert Heinlein)
All Mimsy were the Borogroves (Lewis Padgett)
The Sound of Thunder (Ray Bradbury)
The Garden of Forking Paths, Library of Babel (Jorges Luis Borges)
A Subway Named Mobius (Deutsch)
The Best Time Travel Stories of the 20th Century: Stories by Arthur C. Clarke, Jack Finney, Joe Haldeman, Ursula K. Le Guin

Fiction: novels

The Time Machine (H. G Wells)
The Forever War (Joe Haldeman)
Slaughterhouse 5 (Kurt Vonnegut)
Time's Arrow (Martin Amis)
Einstein's Dreams (Alan Lightman)
The Time Traveller's Wife (Audrey Niffenegger)
Time and Again (Jack Finney)
The End of Eternity (Isaac Asimov)

Movies (in rough order of quality!)

- 1.Sliding Doors *****
- 2.Back to the Future ****
- 3.Run, Lola, Run ****
- 4.Source Code ****
- 5.Slaughterhouse 5 *****
- 6.Primer ***
- 7.The Butterfly Effect ***
- 8.The Time Machine (several) ***
- 9.A Sound of Thunder (Vaguely related to Bradbury) **
- 10.Bill & Ted's Excellent Adventure **
- 11.Hot-Tub Time Machine 
- 12.The Last Mimzy (Vaguely related to the Padgett story) 
- 13.Somewhere in Time (from Time and Again)
- 14.Timecop
- 15.Kate and Leopold

Plays

Dangerous Corner,
I have Been Here Before,
Time and the Conways
An Inspector Calls (J. B Priestley)
Arcadia
Hapgood (Tom Stoppard)

TV

Dr Who; (not many, but try "Blink" in the David Tennant series)
Red Dwarf: (esp. Future Echoes, Time Slide, Stasis Leak, Backwards, Dimension Jump)
Star Trek (some)
Futurama (ugh!)

Journal Articles

***Ford,Roman Scientific American; January 2000, Vol. 282
Issue 1, p46
Stanford Encyclopaedia of Philosophy: Time

Evaluation

- Assignments 30%
- Book report 30%
- Final exam 30%
- Participation 10% (may include talk)

So how do we talk about Time?