Dynamics 2 (MECE08009)

Course Outline

Course Aim:

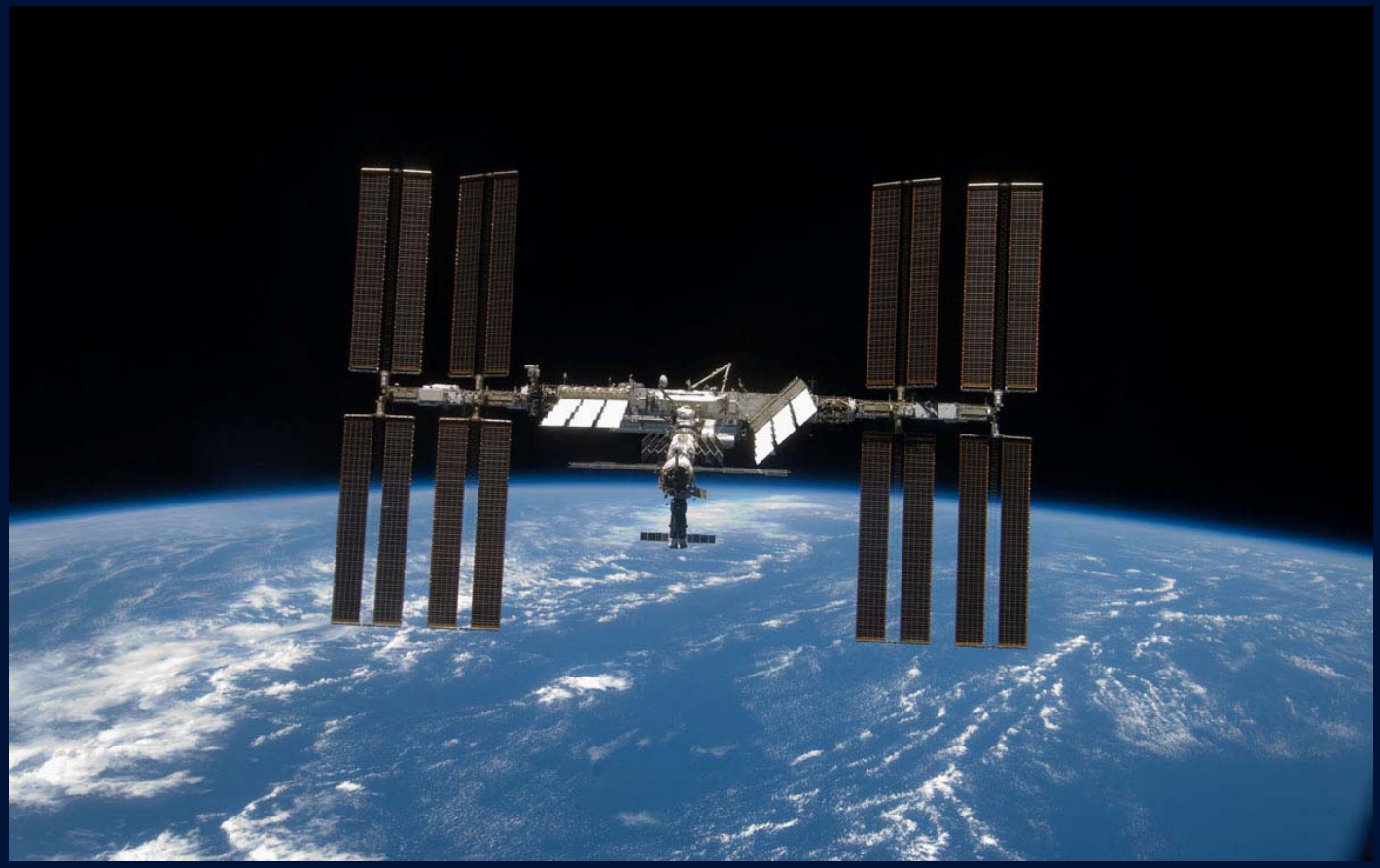
To understand and apply Newtonian Dynamics for bodies and systems in plane motion.

e.g. planes...

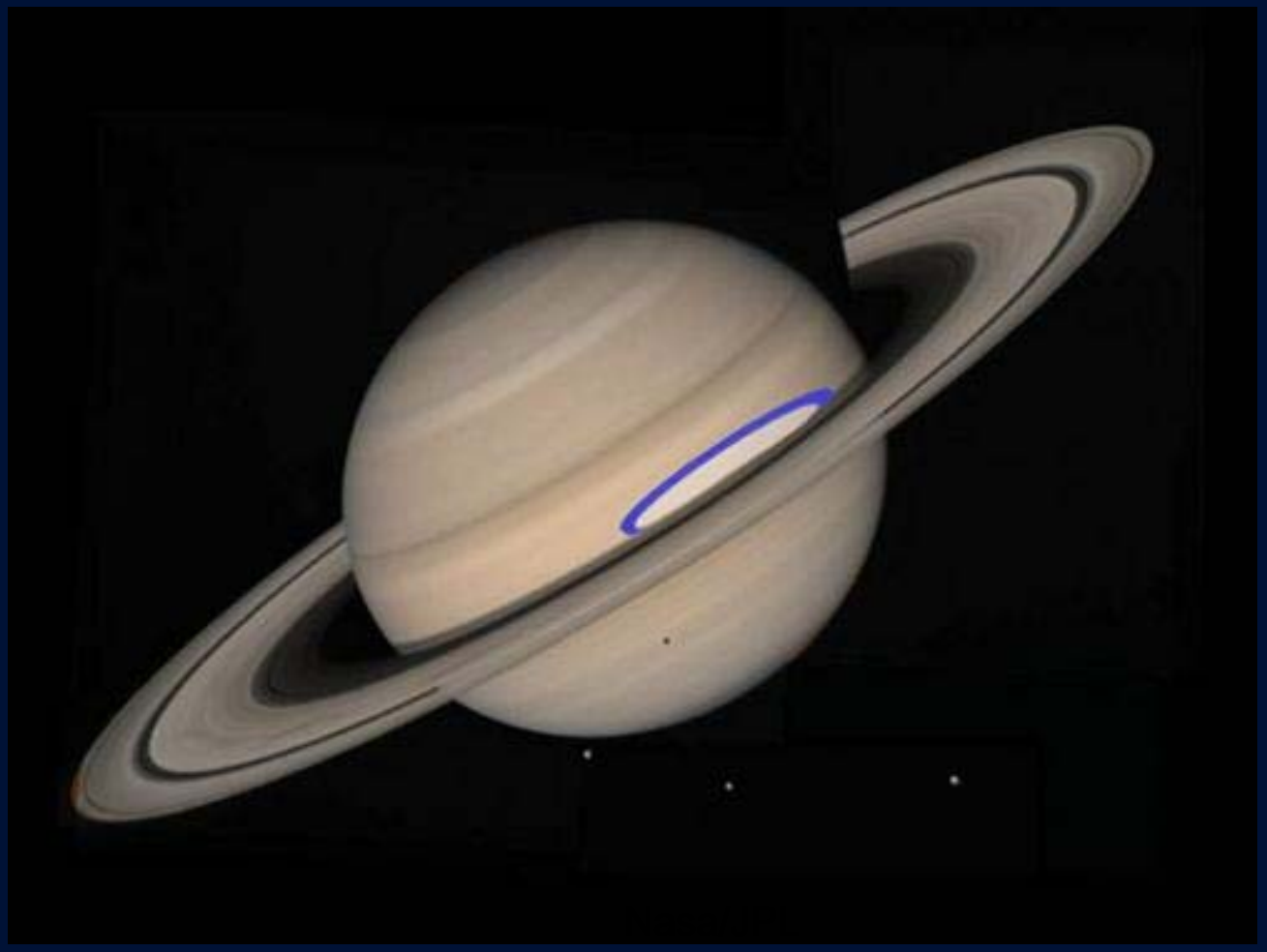
trains...

automobiles...

satellites...



planets...



and...

blocks of wood

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Course Organisation

Organisation

- course organiser: Dr John Chick (john.chick@ed.ac.uk)
- lecture material delivered weekly
- all material will be delivered online: on LEARN
- surgery hours: ad hoc. Discussion board, internet chat etc: whatever works, Teams

Course Material

- copies of PowerPoint slides and typed notes will be provided online as course progresses
- solutions to worked examples will be online after that section has been covered
- tutorial questions online
- tutorial solutions go online after the relevant tutorial
- discussion board
- coursework details and submission online
- course website on Learn

Assessment

- exam in May counts for 50% of final grade: three questions: 3 from 3
- coursework counts for 50% of final grade

- the School has a “40% rule” that applies: ie 40% minimum in both coursework and exam

Coursework

- Jan 31: mini quiz (MCQ) 4%
- Feb 14: mini quiz (MCQ) 4%
- March 07: mini quiz (MCQ) 4%
- March 13: Inertia Lab report submission 10%
- March 21: mini quiz (MCQ) 4%
- March 27: Peerwise questions 4%
- TBC: Gyroscope Lab report submission 20%

all submissions on Learn

Laboratories

- Gyroscope experiment to understand gyroscopic forces. Material on Gyroscopes is will be available online

- Download the lab sheets (and error/graph guidance) from Learn

Laboratories

NB: Although you can discuss the lab with your peers, your Lab Report MUST be your own work.

DO NOT copy the work of others or allow others to copy your work.

Cases of plagiarism will be reported to the academic misconduct officer and will have a detrimental effect on your grade.

Course Syllabus

- dynamics of single particles
- systems of bodies
- work–energy approach
- oscillatory motion
- gyroscopic torque

Recommended Texts

Meriam and Kraige, *Engineering Mechanics: Dynamics*, 6th Edition (SI), Wiley, 2008.

Beer, Johnson and Clausen, *Vector Mechanics for Engineers SI Edition – Dynamics*, 10th Edition, McGraw-Hill, 2013.

Bedford and Fowler, *Engineering Mechanics: Dynamics*, SI Edition, Prentice Hall, 2005.

Hibbeler, *Engineering Mechanics: Dynamics in SI Units*, 12th Edition, Pearson, 2009.

and many other good texts available!

Dynamics 2 (MECE08009)

Presumed knowledge/Revision

Presumed Knowledge

- static equilibrium
  - vector sum of forces = 0, or
  - algebraic sum of force components in any direction = 0 and
  - sum of moments of forces about any specified axis = 0

Presumed Knowledge

- equations of motion (aka SUVAT equations) constant acceleration

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Presumed Knowledge

- position and properties of Centre of Gravity G of a body or system
- linear momentum of particles and use in collisions between particles
- *Mass Moment of Inertia* of a body about a given axis
- circular motion of a particle and *centripetal acceleration*

Presumed Knowledge

- sliding friction and coefficient of friction
  - $F_{max} = \mu N$ at point of slip
- work of forces
  - Kinetic Energy
  - Potential Energy
- Free Body Diagrams

Presumed Maths

- use of sine and cosine for resolving components of forces and other vectors
- basic algebra and calculus, simple integration and differentiation
- complex numbers involving properties of $e^{i\theta}$
- simple first and second order differential equations
- elementary use of vectors and vector algebra results including addition, multiplying by a scalar, dot and vector products

Forces

- forces are vectors
  - they have magnitude and direction
  - generally use components

- three types of forces
  - field forces
  - contact forces
  - inertia forces

Forces

- field forces
  - act *throughout* the body
    eg. weight due to Earth's gravity field

- contact forces
  - act on surface points of the body
  - two types: active and passive

Contact Forces

- active = applied forces
  - may be assigned values
- passive = induced by the other forces
  - eg. at supports
  - normal reactions
    - act at right angles to surfaces at contact points
  - friction forces
    - act parallel to surfaces at contact points
    - wheels sometimes problematic

Forces

- inertia forces
  - an engineering “trick”
  - allows dynamic problems to be solved in similar ways to static ones
  - you will see lots of these!

Newton’s Laws of Motion

- First Law (N1)
- Second Law (N2)
- Third Law (N3)
- Law of Universal Gravitation

Newton’s First Law (N1)

- “A state of rest or uniform motion continues in the absence of a resultant force”
  - special case of Newton’s Second Law
  - don’t really need it in this course

Newton’s Second Law (N2)

- $\mathbf{P} = M\mathbf{a}$
- motion proceeds such that:
  - the resultant force on a mass particle
    = mass × absolute acceleration
- it applies as vector, or algebraically in any direction
- the d’Alembert version used in this course

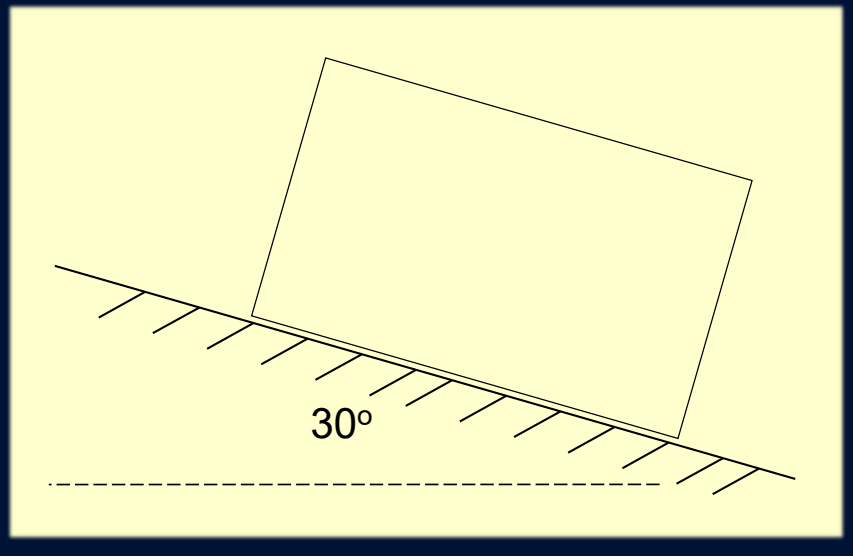
Third and Gravity Laws

- Newton's Third Law (N3)
  - "Every action has an equal and opposite reaction"
    if I push you, I feel you pushing me back

- Newton's Law of Universal Gravitation
  - orbits of satellites etc (not part of this course)

Example 1.1

- block of mass 2 kg on 30° slope
- coefficient of friction $\mu = 0.4$
  - for both static and kinetic friction
- using the standard Newton method determine:
  - if the block slides?
  - if it does slide, what is its acceleration?



Summary

- Revision
- Worked example using Newton’s second law