Engineering Dynamics

COE-C1003

Spring 2024

Professor Gary Marquis

Aalto University
School of Engineering

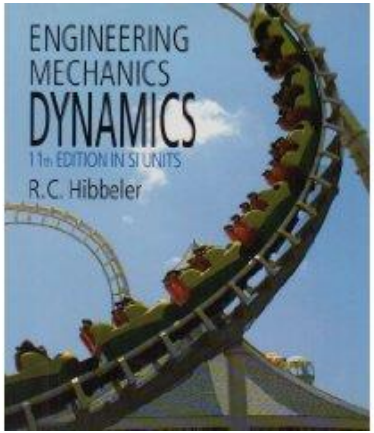
About the course

- Compulsory for students in the Computational Engineering BS programme. Scheduled for the first year.
- Compulsory for students in the Computational Engineering minor.
- EKO and RAK students can choose to study this course instead of the Finnish language version (ENG-C1003)
- KJR and ENY students can replace the discontinued course KJR-C2002 Kontinuumimekaniikan perusteet with either ENG-C1003, COE-C1003 or COE-C2002.

Basic info

- Period V
- 5 ECTS
- Grading will be 0-5
- Lectures (also available via MyCourses) should be sufficient to follow the course. For additional information consult the textbook Engineering Mechanics: Dynamics by Russell C. Hibbeler.
- Lectures: 24h, Exercises: 12h, Exams: 3h, Independent work: 90h
- Course will be assessed based on assignments and exam
- No prerequisites

Material



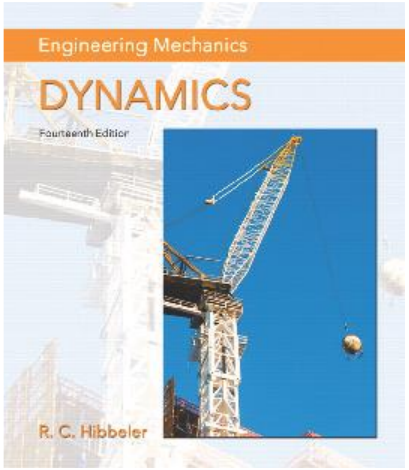
The course will generally follow material in

Engineering Mechanics DYNAMICS

in SI units

By R.C Hibbeler

The book is avaiable from Aalto library or downloadable from internet. Any version from edition 10 to edition 14 are fine.



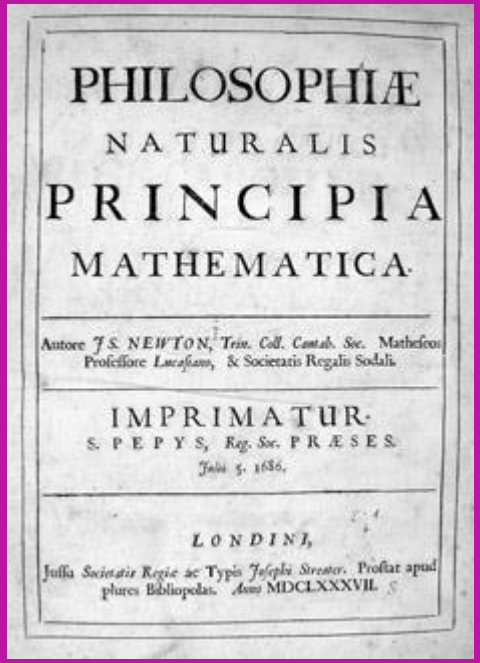
Learning outcomes

After the course, the student will understand the two branches of dynamics

- Kinematics – describing motion
- Kinetics – assessing motion

And will be able to

- Mathematically describe motion of points and objects using several coordinate systems. (kinematics)
- Apply Newton’s three laws of motion to engineering objects in several coordinate systems. (kinetics)
- Apply concepts of work, energy, impact and momentum (as extensions of Newton’s three laws) to solve engineering challenges


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *Is. NEWTON*, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Justu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

Isaac Newton 1687

What is Mechanics / Dynamics?

Mechanics – The study of physical bodies subjected to forces and displacements

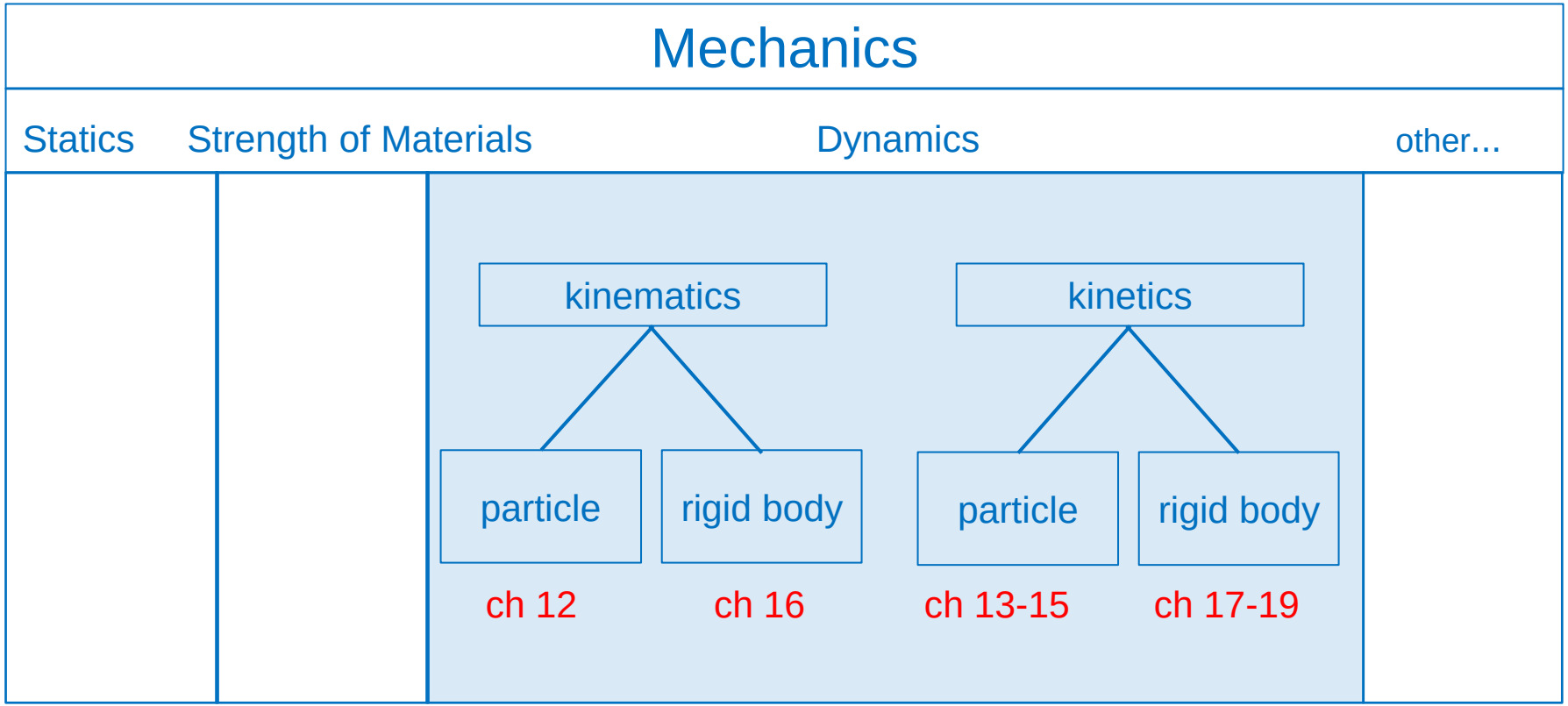
Statics – Objects in equilibrium (not moving)

Dynamics – Objects in motion

1) Kinematics – Describing motion without consideration of what causes the motion.

2) Kinetics – the study of motion and its causes: the influence of forces on motion of bodies.

Introduction



Introduction

COE-C1003 Dynamics
Kirja: R.C.Hibbeler : Engineering Mechanics Dynamics, 14th edition (2017), SI Units, Prentice Hall
as reference, students may refer to: T. Salmi ja S. Virtanen, Dynamiikka, Klingendahl paino, 2006

Professor Gary Marquis, office hours by appointment, Otakaari 4 room 142a

Course outline Spring 2024

Topic #	Topic	Readings (Hibbeler)	Lecture review, questions and homework review 10:15-12:00	Homework set due	Exercise time to look at HW problems due the next week 10:15-12:00
1	Introduction to dynamics, particle kinematics and motion in different coordinate systems	12.1-12.7, 12.9	23.4 K1 326	30.4 10:00 HW set 1	25.4 K1 326
2	Equations of motion in different coordinate systems	13.1-13.6	30.4 K1 326	7.5 10:00 HW set 2	2.5 K1 326
3	Work and energy of a particle and Introduction to impulse	14.1-3, 14.5-6 and 15.1-2	7.5 K1 326	14.5 10:00 HW set 3	10.5 K1 216 (Friday)
4	Impulse and momentum of a particle Introduction to kinematics of a rigid body	15.3-7 16.1-4	14.5 K1 326	21.5 10:00 HW set 4	16.5 K1 326
5	Kinematics of a rigid body and Equations of motion for a rigid body	16.5-16.7 17.1-17.5	21.5 K1 326	28.5 10:00 HW set 5	23.5 K1 326
6	Work and energy of a rigid body and Impulse and momentum of a rigid body	18.1 – 18.5 19.1-19.3	28.5 Undergraduate centre (Kandikeskus) U9-U271	4.6 10:00 HW set 6	30.5 K1 326
	Exam 3 June 2024 9:00 – 12:00 D-hall Y-122 Undergraduate centre				

Introduction

All lectures and exercise examples are pre-recorded and available from ***MyCourses***. These are about 120-150 minutes per week

Tuesdays

- Questions about video lectures
- Review returnable exercise that are due just before class begins

Wednesdays

- No lectures

Thursday

- Q&A about returnable problems for the next week

Weekly problems

Each week there will be 5 returnable problems

Each problem will be worth 2 points (max. 10 points per week)

The weekly returnable problems, recorded demo problems and exam problems are all very similar

The course will be assessed based on assignments and exam.

In order to qualify to take the exam, students must receive a minimum cumulative score of 60% (36 points) on all the weekly assignments.

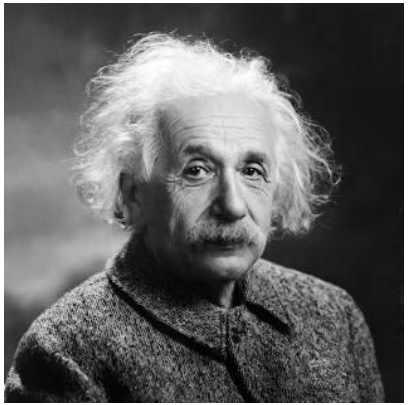
Grading

Students who perform well on the weekly assignments will have extra points added to their score on the final exam. The final exam will have a maximum of 100 points. Bonus points from the weekly assignments are as follows:

Exercise points	Bonus points
40	1
44	2
48	3
53	4
57	5

The course score will be	90+	5
	80+	4
	70+	3
	60+	2
	50+	1
	49-	0

Exam Prep.



“Never memorize something that you can look up.”

Aalto University
School of Engineering

COE-C1003 Dynamics equations (Dynamiikka kaavoja)

Basic Units (Perussuureet)

position (asema) $\vec{r}$ [m]

time (aika) t [s]

mass (massa) m [kg]

Derived units (Johdannaissuureita)

force (voima) $\vec{F}$ [N]

velocity (nopeus) $\vec{v} = \dot{\vec{r}} = \frac{dr}{dt}(\rightarrow)$

acceleration (kiihtyvyys) $\vec{a} = \dot{\vec{v}} = \frac{dv}{dt}\ (\rightarrow)$

displacement-velocity-acceleration (siirtymä-nopeus-kiihtyvyys) $ads = vdv$

momentum (liikemäärä) $\vec{P} = m\vec{v}$

angular momentum (liikemäärän momentti) $\vec{H}_O = \vec{r} \times m\vec{v}$

force moment (voiman momentti) $\vec{M} = \vec{r} \times m\dot{\vec{v}}$

linear impulse (voiman impulssi) $\vec{I} = \int \vec{F}(t)dt$

angular impulse (voiman momentin impulssi) $\int \vec{M}_O dt = \int \vec{r} \times \vec{F} dt$

kinetic energy (liike-energia) $T = {mv^2}/{2}$

power (voiman teho) $P = \vec{F} \cdot \vec{v}$

work done by a force (voiman työ) $U = \int \vec{F} \cdot d\vec{r}$

gravitational potential energy (painovoiman potentiaalienergia) $V_g = mg\Delta y$

conservation of energy priciple (energian säilymisen lause) $T_1 + V_1 = T_2 + V_2$

work energy principle (työ ja liike-energia lause) $T_1 + \sum U_{1-2} = T_2$

work done by a linear spring (jousivoiman työ) $U_s = -\left(\frac{1}{2}ks_2^2 - \frac{1}{2}ks_1^2\right)$

Basic physical laws (Peruslait)

Newton’s 2nd law (liikelaki) $\vec{F} = m\vec{a}$

Newton’s 3rd law (voiman ja vastavoiman laki) $\vec{f}_{ij} = -\vec{f}_{ji}$

Constituitive relationships (Konstitutiivisia yhteyksiä)

spring (jousi) $F_s = k(s - s_0)$

rotational spring (vääntö jousi) $M_s = k_\theta(\theta - \theta_0)$

damper (vaimennin) $F = k\dot{s}$

gravity (gravitaatio) $F = mg$

Coulomb friction (Coulombin liikekitka) $F = \mu_k N$

static friction (lepokitka) $F \leq \mu_s N$

restitution equation (sysäysyhtälö) $e = ((v_B)_2 - (v_A)_2)/((v_A)_1 - (v_B)_1)$