

ME623

Dynamics of Machining Processes



ME623: Dynamics of Machining Processes
Instructor: R K Mittal



Outline

- Contact details
- Instructions
- Grading policy
- Course objectives



Instructors

- **Course Instructor:**
Prof. R K Mittal
- **Classroom:**
L1
- **Teaching Assistants (TAs):**
Debottam Bhowmik: b.debottam@iitg.ac.in
Abhishek Punia: a.punia@iitg.ac.in



Contact Details

Prof. R K Mittal

Room: DX210 (ME-Extension Building)

E-mail: rkmittal@iitg.ac.in

Tel: 3576

Office Hrs.: Monday 4-5 PM. (also by appointment)

Course Website: www.iitg.ac.in/rkmittal/me623



Contact Details

- Teaching Assistants :

- Debottam Bhowmik (b.debottam@iitg.ac.in)
- Abhishek Punia(a.punia@iitg.ac.in)

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|----------------|------------|---------------------|
| Class Timings: | Tuesdays | 9:00 AM – 9:55 AM |
| | Wednesdays | 10:00 AM – 10:55 AM |
| | Thursdays | 11:00 AM – 11:55 AM |
| Classroom: | L1 | |



Grading Policy

| | |
|--------------------------|-------|
| Quizzes | 20% |
| Project | 15% |
| Midterm Exam | 25% |
| End Semester Examination | 40 % |
| Total | 100 % |

Attendance is not optional. FA grade will be awarded for attendance less than 75%



Important Instructions

- Lecture notes and homeworks will be posted on **the course website or through shared folder**
- Home assignments will be submitted **in a self-selected group of three** and are due in class on **the submission date**. **No late submission will be accepted.**
- Any form of uncanny similarity or copying on the homework **will be severely penalized.**
- **Hands on projects** which involves experimental analysis will be preferred.



Important Instructions

- Students could opt for an analysis project either using Deform/commercial finite element code or analytical techniques.
- **Surprise quizzes** may be there in classes.
- **No cellphones on the desk. Cell phones should be either in your bag or pocket.**
- It would be good if we all learn together – the more two-way interactions, the better for all of us. I will make mistakes, which you will be expected to correct, and vice versa!



Dynamics



[Youtube link](#)

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Dynamics



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Objective of Course

- Learn the principles of material removal mechanisms of conventional machining
- Develop first order mathematical descriptions for selected machining processes such as turning, milling, and drilling processes.
- Mathematical modelling of chatter vibrations in both orthogonal and oblique machining operations
- Learning of basic concepts of single and multiple degrees of free and forced vibrations
- Introduction to analytical and experimental modal analysis techniques



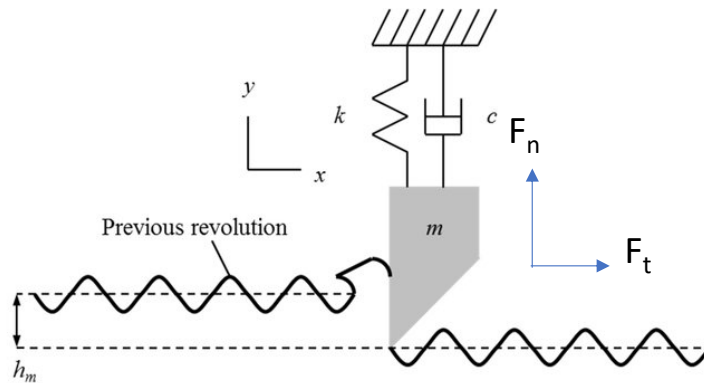
Objective of Course

- **Stability analysis of machining operations** both in the frequency and time domain
- Introduction to **different chatter detection and suppression techniques**
- Emphasis on understanding **the physical principles** underlying these processes
- **Encourage teamwork and group activity via group assignments and Project.**

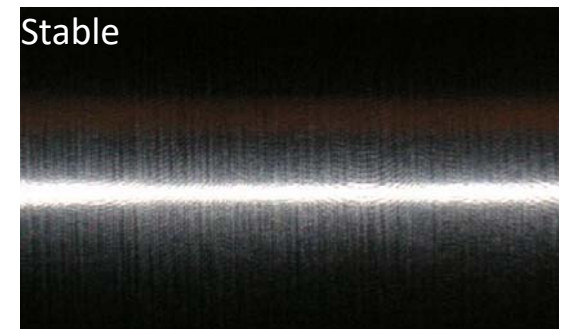
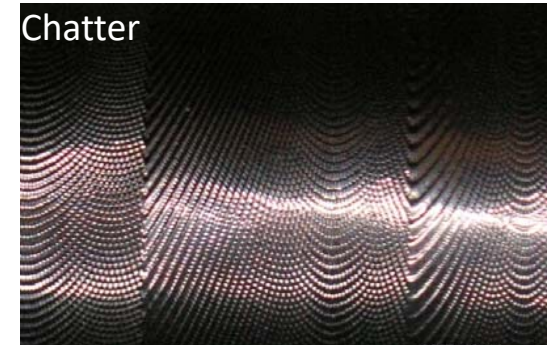


Self Excitation Vibration: Chatter

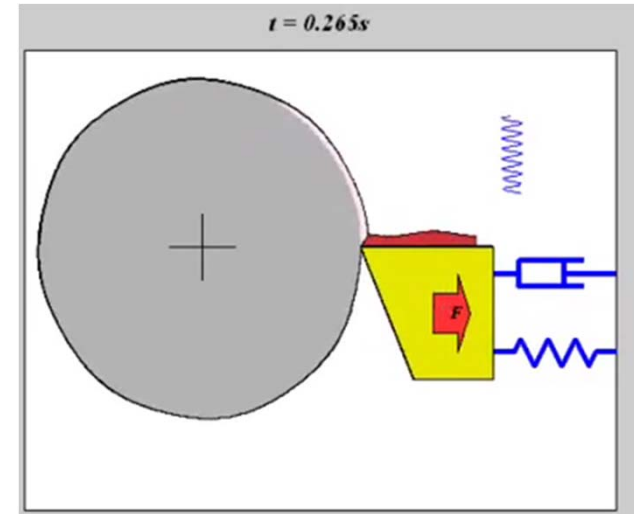
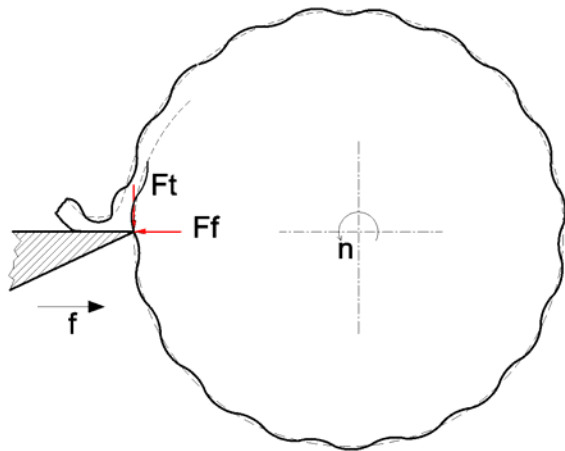
- Dynamic interaction between process and structure
- Applied force is due to the process itself, not external
- It appears due to instability in the process
- Vibration amplitude increases continuously
- The cutting force becomes periodically variable, and the machined surface becomes undulated and the chip thickness varies in the extreme
- The most significant cutting parameter, which is decisive for the generation of chatter, is the width of cut (width of chip)



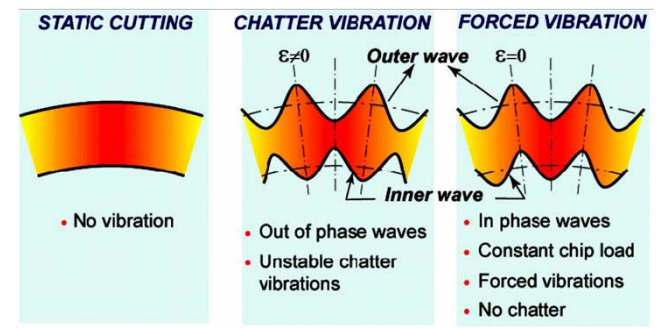
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Self Excitation Vibration: Chatter



Cutting Forces
+
Dynamic chip thickness changes due to vibrations between the tool and workpiece





Course Outline

- **Mechanics of machining processes:** Physics of orthogonal cutting and oblique cutting; Analytical, mechanistic modelling for cutting forces in turning, milling (straight and helical cutters), and drilling processes; Analytical and experimental methods for Identification of cutting force coefficients.
- **Machining dynamics and chatter vibrations:** Mathematical modeling of single and multiple degrees of free and forced vibrations; Frequency response functions; Analytical and experimental modal analysis of machines tool structures; Oriented frequency response function of machine tool structures; Identification of modal parameters; Introduction to chatter or self-excited vibrations; Types of chatter; Regenerative chatter mechanism; Mathematical models for regenerative chatter in orthogonal cutting operation.



Course Outline

- **Stability Analysis:** Stability analysis of single and multiple degrees of freedom models of orthogonal cutting operation; Stability modelling of turning process and milling operations using frequency and time domain approach; Introduction of stability model for drilling process.
- **Chatter detection and suppression techniques:** Prediction methods and experimental techniques for chatter avoidance; Passive and active suppression techniques.



Project Work

- Group of three students
- Hand on project/ Analysis Project/ Simulation work
- Product-based or analysis based (Preferably analysis based)
- Presentation will be conducted before end sem exam
- Presentation of 10 minutes each group



Textbooks and Reference books

- Yusuf Altintas, Manufacturing Automation: metal cutting mechanics, machine tool vibrations, and CNC design, 2nd Ed., Cambridge University Press, 2012
- Tony L. Schmitz and Kevin, S. Smith, Machining Dynamics: frequency response to improved productivity, 1st Ed., Springer Science & Business Media, 2009
- Kai Cheng, Machining dynamics: fundamentals, applications and practices, Springer Science & Business Media, 2008
- George Tlusty, Manufacturing Process and Equipment, 1st Ed., Pearson Education, 1999
- Koenigsberger, Franz, and Jiri Tlusty. Machine tool structures, 1st Ed., Elsevier, 2016
- Weihong Zhang and Min Wan, Milling simulation: metal milling mechanics, dynamics and clamping principles, Wiley-ISTE, 2016