Lecture notes:

Engineering: application of scientific principles to design, build and maintain structures, machines, devices, systems and processes

[illegible] (concept practical application)

1) [illegible] problems

2) Innovation and progress

3) Economic growth

4) Improving quality of life

Model systems: creating models [illegible] real-world behaviour (e.g. electrical circuits)

Analyze data: [illegible] insights and optimize the [illegible] solutions

Solve problems: provides tools to solve engineering problems

Steps of scientific method

1) Ask a question
2) Do background research
3) Construct a hypothesis
4) Test the hypothesis
5) Analyze data, conclude
6) Communicate the results

Engineering domains: [illegible], technologies, [illegible], [illegible]

Engineering design process

1) Define the problem
2) Do background research
3) Specify requirements
4) Brainstorm solutions
5) Choose the best solution
6) Develop the solution
7) Build a prototype
8) Test and redesign
9) Communicate results

Industrial design

- Cost reduction
- More productivity
- More precision and quality

Research and development (R&D)

- Novel
- Creative
- Uncertain
- Systematic
- Transferable and/or reproducible

[illegible] → [illegible] → Basic research → Applied research → Development → Innovation → Diffusion

---

Innovation

Product innovation: the quality of a product or the introduction of an existing product with [illegible]

Service innovation: changing and [illegible] the services

Marketing innovation: [illegible]

to [illegible]

Organizational innovation: [illegible] through continuous [illegible] and development of new [illegible], [illegible] and organizational [illegible]

Business model innovation: [illegible]

Innovation [illegible] steps: [illegible]

Process steps:

1) Idea generation & [illegible]
2) (Feasibility [illegible] and experimentation)
3) [illegible]
4) Commercialization and [illegible]
5) [illegible] and implementation

Examples: [illegible], artificial intelligence (AI), machine learning, cloud computing, internet of things (IoT), [illegible]

Steps of strategic plan:

1) Determine where you are
2) Identify your goals and objectives
3) Develop your plan
4) Execute your plan
5) [illegible] and restructure as needed

Ethics

[illegible] ethics: [illegible]

[illegible] ethics: [illegible]

Scientific data collection and measurement methods

- Surveys and questionnaires
- Observation
- Interviews
- Experiment [illegible]
- [illegible]
- [illegible]

Validity

Extent to which a measurement tool or method accurately measures what it is intended to measure. It [illegible] whether the [illegible] are appropriate for the research question.

Internal validity: whether the independent variable truly affects the dependent variable in experimental research

External validity: whether the research results can be [illegible] beyond the environment in which [illegible]

Face validity: [illegible]

Reliability:

Extent of the consistency of a measurement [illegible] whether the [illegible] produces the same results under the same conditions [illegible]

Test-retest reliability: [illegible]

Internal consistency: [illegible]

Inter-rater reliability: [illegible]

Ethical issues in scientific research

- Conflicts of interest (personal interest can [illegible] [illegible] by researchers' [illegible])
- Data manipulation (altering research data [illegible] to [illegible] in the [illegible])
- Privacy violations (collecting or misusing personal data without consent)
- Misinterpretation of research findings (incomplete or misleading manner)

Wrong engineering practices
1. Ignoring safety standards
2. Poor material selection
3. Falsifying test results
4. Neglecting environmental impact
5. Ignoring maintenance protocols
6. Designing for cost over quality
7. Using outdated or inadequate technology
10. Disregarding ethical considerations
11. Lack of transparency
12. Lack of proper documentation
13. Inadequate risk assessment

Ethical principles in scientific research

- Autonomy
- Honesty
- Justice
- Non-maleficence (do no harm)
- Informed consent
- Confidentiality and privacy
- Compliance

IT presentation

IT infrastructure: hidden foundation [illegible], [illegible] digital services [illegible], ensures system [illegible]: [illegible], secure and always available
→ 5G, AI, and cloud computing
- Server: run applications
- Storage: keep data safe
- Database: organize and store information
- Network: connect everything together

Project management

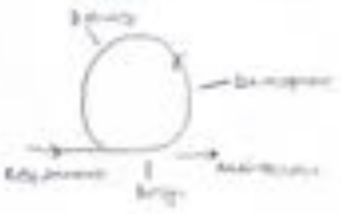
Planning, organising and managing resources to deliver a unique product, service or result within defined constraints
quality → scope, cost, time
initiating → planning → executing → monitoring / controlling → closing
(change request)

Frameworks and methodologies

eg Agile, waterfall, lean, scrum, critical path method (CPM)

Waterfall
Requirements
↓
Design
↓
Development
↓
Testing
↓
Maintenance
(linear and step structure)

Agile



(flexibility, short cycles, continuous [illegible])

+ Stakeholder [illegible]	+ [illegible]	+ Communication
- understand needs	- [illegible] risks	- specify [illegible]
- engage regularly	- analyze [illegible]	- [illegible] [illegible]
- clear, [illegible]	- [illegible]	- [illegible]

Common tools: Jira (Agile [illegible]), MS project (scheduling), Trello (task tracking), [illegible] / [illegible] ([illegible]), [illegible] ([illegible], KPIs)

Business Process Management (BPM)

Approach to designing, executing, monitoring and improving business processes to achieve organizational goals
- improve efficiency, reduce [illegible] [illegible] - [illegible] [illegible] [illegible], [illegible]

1) Design (identify) 2) Model (simulate) 3) Execute (action) 4) Monitor (measure) 5) Optimize (improve)

BPM tools and techniques
i) [illegible], [illegible], and [illegible]

Standardization: [illegible] [illegible] [illegible] [illegible] [illegible]
Continuous improvement (Kaizen): [illegible] [illegible] [illegible]
Automation: [illegible] [illegible] [illegible] [illegible]
Measurement: [illegible] [illegible] [illegible] performance [illegible]
Optimization: [illegible] [illegible] [illegible] [illegible]

Project Management: [illegible] [illegible] [illegible] [illegible] [illegible] (one-time goals)
Process Management (BPM): [illegible] [illegible] operations [illegible] [illegible] (repetitive, ongoing [illegible])

Waterfall: follows a linear and sequential structure
Agile: emphasizes flexibility, iterative development and [illegible] [illegible] through short cycles

2nd presentation

Software development
Process of designing, coding, testing, deploying and maintaining software applications or [illegible] [illegible]

Software engineer/developer
- Writes, tests and maintains code
- Specializing in frontend, backend or full-stack development

Frontend
- User facing part of an app (UI, UX, visuals)

Backend
- Server-side logic, databases, and application [illegible]

Software architect
- Designs overall system structure, technology stack, scalability and security of software systems

QA engineer (Quality Assurance)
- Tests software to detect bugs and ensure quality
- Creates automated and manual test plans

DevOps engineer
- Bridges development and operations teams
- Manages CI/CD pipelines, cloud infrastructure, and deployment

CI/CD (Continuous Integration / Continuous Deployment)
- Automates process: builds, tests, and deploys software [illegible] to improve reliability and speed

UI/UX designer
- Designs user interfaces and improves user experience
- Collaborates with developers to create intuitive applications

Product manager
- Defines the product vision and prioritizes features
- Balances technical and business needs

Data scientist / AI engineer
- Analyzes large datasets, builds machine learning models
- Applies AI techniques to optimize business processes

Team lead / technical lead
- Guides developers, reviews code, ensures technical direction
- Bridges engineering team and management

Project manager / Scrum master
- Plans, organizes, and monitors software projects
- Uses Agile or Scrum methodologies to track progress

CTO (Chief technology officer)
- Defines company's overall technology strategy
- Aligns engineering goals with business objectives

API (Application programming interface)
- Enables communication between software components

Version control (Git)
- Tracking and managing changes in code

3rd presentation

Product management
Blend of [illegible], product development, marketing, sales, business operations, support, finance, customer success, leadership and strategy

[illegible] A product manager [illegible] for defining what to build, why to build it and how success will be measured, while [illegible] business, technology, and user needs

Benchmarking
Comparing products or processes with industry leaders to identify best practices

Product strategy
Process of turning insights, goals, and ideas into a clear, testable product proposal

Product lifecycle management

NPS (Net Promoter Score)
Measures customer loyalty by asking "How likely are you to recommend us to a friend, [illegible] [illegible] [illegible]?"

Retention
The percentage of users who continue using your product over time. Shows how well you keep them.

Churn rate
The percentage of customers who stop using your product within a given time period

Conversion rate
The ratio of users who take a desired action out of total

RICE framework
A prioritization method: Reach × Impact × Confidence ÷ Effort; helps decide what to build first

MoSCoW method
Prioritization into: Must have, Should have, Could have, Won't have (this time)

Impact & Effort matrix
A 2×2 grid used to decide priorities: focus on high impact, low effort

OKR (Objective and key results)
Goal setting framework combining what you want to achieve and how you'll measure success

Agile
A flexible way of working that delivers products incrementally, learning and adapting quickly

Sprint
A short, time-boxed cycle where the team builds, tests, and delivers specific output

Backlog

- A prioritised list of features, bugs and tasks [illegible]

Roadmap

- A visual plan [illegible]
- Strategic [illegible] product [illegible]

North Star Metric (NSM)

- Single metric that best captures your product's long-term value for customers

MVP (Minimum Viable Product)

- The simplest version of a product that delivers value and helps validate [illegible]

A/B test

- An experiment comparing two versions (A and B) to see which performs better

Agility

- Ability to adapt changes in [illegible] environment [illegible] changes

Strategic	Tactical	Operational
[illegible]	[illegible]	[illegible]

Focus

- [illegible]
- Continuous improvement of the product and [illegible]
- [illegible]
- [illegible] with the customer
- Delivering products that [illegible] customer needs

Focus [illegible] / Focus [illegible]

- [illegible]

Focus [illegible] / Continuous [illegible]

- [illegible]

Organisational perspective change

Traditional
- [illegible]

Agile
- [illegible]

Waterfall

- Ideal for construction and engineering
- [illegible]
- [illegible]

Requirements → Design → [illegible]

Kanban

- [illegible]

Kanban board

- [illegible]

Analysis	Design	Development	Test

Iteration

Daily meeting

[illegible]

Scrum

- [illegible] software development [illegible]
- [illegible]
- [illegible]

Core elements (3 pillars)

- Transparency
- Inspection
- Adaptation

Values

- Courage
- Focus
- Commitment
- Respect
- Openness

Roles	Artifacts	Events
Product owner	Product backlog	Sprint planning
Developers	Sprint backlog	Daily scrum
Scrum master	Increment	Sprint review
		Sprint retrospective
		Sprint

[illegible]

Self-managing

[illegible]

Cross-functional

[illegible]

Product Owner

The person who defines product features / [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] completion [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

- Vision and [illegible]
- Product [illegible]
- [illegible] [illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

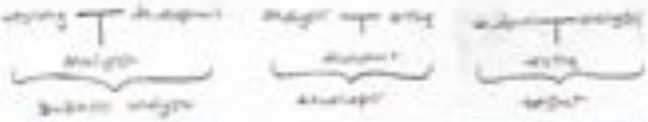
Scrum master

- [illegible] [illegible] agility
- Facilitates events
- [illegible] servant leadership
- [illegible] [illegible] [illegible]

[illegible]

Scrum team

- Cross-functional: [illegible]
- Self-organizing: [illegible]
- Self-managing: [illegible]
- Collaboration: [illegible]



Product backlog

- [illegible] prioritized and [illegible] [illegible], [illegible] stories, bugs, and [illegible] [illegible]

Minimum viable product (MVP)

- [illegible]
- [illegible] [illegible] [illegible] [illegible]

DoR - Definition of Ready

- A list of clear conditions that [illegible] a work item is "Ready" to be taken [illegible] [illegible] [illegible] [illegible]

DoD - Definition of Done

- A list of [illegible] and [illegible] [illegible] that [illegible] [illegible] [illegible] [illegible] work item [illegible] [illegible] considered "Done"

Scrum events

- Sprint ([illegible])
- Sprint planning ([illegible])
- Daily scrum ([illegible]) → yesterday? → today? → [illegible]?
- Sprint review ([illegible])
- Sprint retrospective ([illegible])

Sprint planning

- The sprint goal is defined — PO, SM, DT
- [illegible]
- At the beginning of sprint

Input

- Product backlog [illegible]
- [illegible]
- [illegible]

Output

- Sprint goal
- Sprint backlog [illegible]

Actions

1) PO [illegible] [illegible] [illegible] in sprint
2) [illegible] [illegible] [illegible] they can complete
3) PO [illegible] [illegible] [illegible]
4) [illegible]
5) [illegible]
6) [illegible]
7) [illegible]
8) [illegible]
9) [illegible]
10) [illegible]

Daily scrum

- [illegible] sprint goal [illegible]
- [illegible] [illegible] [illegible] [illegible]
- PO, SM, DT
- [illegible]

Actions

1) [illegible]
2) SM [illegible]
3) [illegible]
4) [illegible]
5) SM [illegible]

Sprint review

- [illegible]
- PO, SM, DT, [illegible] — [illegible] every sprint

Input

- [illegible]

Output

- [illegible]
- [illegible] suggestions

Actions

1) [illegible]
2) [illegible]
3) [illegible]

Sprint retrospective

- [illegible] sprint
- Opportunity [illegible] [illegible] improvements [illegible] upcoming sprint
- PO, SM, DT — [illegible] sprint

Input

- [illegible]

Output

- Improvements [illegible]
- [illegible]

Actions

1) PO [illegible]
2) [illegible]
3) [illegible]
4) [illegible]
5) [illegible]

5th presentation

Software

- Group of machine commands that enable communication of the electronic device

Software development life cycle (S.D.L.C)

planning
- time
- source
- requirements

analysis
- determining solution
- specification
- feasibility

design
- system architecture
- user interface

coding
- development
- configuration

testing
- error detection
- quality standards
- evaluation
- user documents

maintenance
- continuity
- correcting

Software testing

- Systematic process which verifying that the requirements established for system or product are met, accurate outcomes and user evaluations are [illegible]

target
- Detecting errors
- Providing info for decision making
- Confidence about quality
- Preventing errors

testing principles

1) testing and presence of defects [illegible]
2) exhaustive testing is impossible
3) early testing
4) defect clustering
5) pesticide paradox
6) testing is context dependent
7) absence of errors fallacy

testing process

waterfall model

planning → analysis → designing → development → testing → maintenance

V model

planning ⟶ user acceptance testing
analysis ⟶ system testing
designing ⟶ integration testing
development with unit testing

Agile model

Sprint 1	Sprint 2	. . .	Sprint n
· Planning			
· Analysis			
· Designing			
· Development			
· Testing			

Test levels and types

Functional testing

- Evaluates whether the software performs the functions specified in the requirements. Focuses on inputs, outputs, user interactions, and system behavior including what should do and not do.

Non-functional testing

- Assesses how well the software performs its functions rather than what it does. Focuses quality attributes such as performance, usability, reliability, maintainability and portability, which based on standard ISO [illegible]

Retest

- Test performed to confirm the corrected error

Regression test

- Performed to confirm that corrected error does not cause other errors

---

Risk

- Impact and probability of situations which may have adverse consequences if it occurs
- Risk in the software process, represent possible errors which occur when the product is taken into use by the customer

Risk identification

- Expert comments
- Risk analysis
- Checklists
- Experiences

Risk = impact x probability

Impact

- [illegible]
- [illegible]

Probability

- [illegible]
- [illegible]

Risk types

Project risks

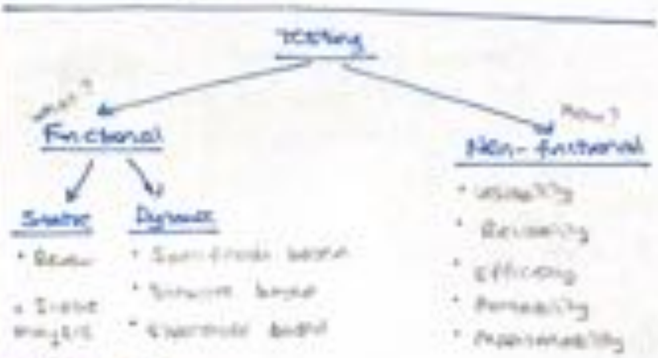
- [illegible]

Product risks

- [illegible]

Defect report

- Environment
- Scenario
- Actual and Expected result
- Data
- Detection time
- Priority
- Severity
- Previous attempt
- Tester



Static testing

- Performed to check defects without executing code

Review

- Informal • walkthrough • Technical review • Inspection

Static analysis

- [illegible]

Dynamic testing

- [illegible]
- [illegible]

- Specification based
- Structure based
- Experience based

Equivalence partitioning

- [illegible]

Boundary value analysis (BVA)

- [illegible]

Decision table

- [illegible]

State transition

- [illegible]

Performance testing

- [illegible]
- [illegible]

Load testing

- [illegible]

Stress testing

- [illegible]
- [illegible]

Reliability testing

Static code analysis

- [illegible]
- [illegible]

Penetration testing

- [illegible]

Usability test

- [illegible]

5 components:

- Learnability
- Efficiency
- [illegible]
- Error [illegible]
- Satisfaction

Test data management

• Provisioning • Masking • Creation • Cleansing

• Process of analyzing test data requirements, designing test data structures, creating and maintaining test data

• Ensures that test data is accurate and provided to the test environment, preventing errors caused by faulty data and saving time.

Test automation

1) Purpose ?

2) Making and maintenance ?

3) Infrastructure ?

4) Modularity ?

5) The difference between manual and automation

• Unit testing

• Regression testing

• Exploratory testing

• Multi-platform testing

Test-driven development (TDD)

• Development approach where tests are written before code

Behavior-driven development (BDD)

• BDD extends TDD by focusing on software behavior and user scenarios written in natural language, improving collaboration between developers, testers, and stakeholders

Data [illegible]

Datum: refers to a single indivisible unit of information or measurement

Data: represents multiple units of information collectively used for analysis and interpretation

Data life cycle

1. Data generation and collection

Data is generated from various sources, IoT devices and digital platforms

2. Data storage and [illegible]

Data is stored in databases, data warehouses or cloud platforms

3. Processing and transformation

Raw data is cleaned and transformed via ETL process

4. Analysis

Analytics and AI tools extract insights, patterns and trends

5. Sharing and usage

Insights are distributed [illegible] to support organizational decisions

Some of data management [illegible]

1) Cloud-based

Provides scalable, flexible, cost-efficient infrastructure that supports storage, processing and analytics across distributed environments

2) AI and machine learning integration

Enables faster and more accurate insights, empowering businesses to be more proactive and adaptive

3) Data democratization and self-service analytics

Refers to making data accessible to non-technical users through self-service tools, enabling organization-wide data-driven decision-making

4) Real-time analytics

Rapid data processing, streaming data platforms and edge computing are allowing businesses to make [illegible] decisions with minimal latency

Vector databases

Store numerical embeddings of data and enable semantic similarity search using mathematical operations

Data warehouse (DWH)

Centralized system designed for analytical processing optimized for reporting, historical analysis, and decision support rather than transactional operations

data warehouse → data lake → lakehouse

Large language models (LLM)

Vector databases store numerical embeddings that represent data in a high-dimensional space, enabling LLMs such as [illegible] to retrieve relevant [illegible] documents

Linear algebra

For matrix and tensor operations

Probability theory

For prediction and uncertainty modeling

Calculus

For optimization via gradient descent

ETL (Extract, Transform, Load)

• Extracting

Data from source systems

• Transforming

Into a consistent, quality-controlled format

• Loading

Into a data warehouse or analytics platform

4th presentation

Right ... [illegible]

[illegible]

[illegible]

[illegible]

The [illegible]

[illegible]

- Employer's freedom to work · Right ... [illegible]
- [illegible] of forced labour · Employer's freedom of [illegible]

Labour Law (No 4857) → [illegible] defined as employees

Turkish Code of Obligations → not defined as "employee"

Labour Courts Law regulating procedural principles

Principal employer – subcontractor relationship: exists when a principal employer assigns [illegible] to another employer, [illegible]

Types of employment contracts

Indefinite – Term

→ end date not specified [illegible]

→ Job security provisions applied

Fixed – Term

→ Duration determined, ends upon expiry

→ [illegible]

→ [illegible]

→ Job security [illegible]

Job security

→ [illegible] indefinite-term contract

→ [illegible]

→ [illegible] 6 months of seniority

→ [illegible] employer's representative

According work time

Full-time

→ weekly 45 hours

→ Full wage and benefits

Part-time

→ [illegible] full-time hours

→ Rights apply proportionally

→ [illegible]

According working method

Probationary

→ max 2 months [illegible]

→ [illegible] without notice [illegible]

→ [illegible]

Remote work

→ [illegible]

→ [illegible]

→ [illegible]

Special

On-call work

→ [illegible]

Temporary

→ [illegible]

⇒ Actual working relationship is decisive, [illegible] contract

Basic principles of labour law – obligations

Employer

- Pay wages
- Treat equally
- [illegible]
- [illegible]
- Comply with [illegible]

Employee

- Perform duties diligently
- [illegible] loyalty
- Follow instructions
- [illegible]
- [illegible] confidentiality
- Comply with [illegible]

Fundamental changes in working conditions

→ Notified in writing

→ Approved in writing by employee within 6 working days

Wages

Must be paid [illegible]

- Gross basic wage
- Net basic wage
- Gross wage including benefits
- Net wage including benefits

Turkish [illegible]

Working hours

[illegible] 45 hours · Daily [illegible] 11 hours

Rest periods

- 15 min for up to 4 hours
- 30 min for 4–7.5 hours
- 1 hour for over 7.5 hours

Overtime (exceeding 45 hours per week)

- [illegible]

Leaves

Annual paid: [illegible] after one year of service, [illegible]

1–5 years → 14 days · 15+ years → 26 days

5–15 years → 20 days · [illegible] → 20 days

Public holidays

- Entitled to pay if they do not work
- If they work, receive double pay

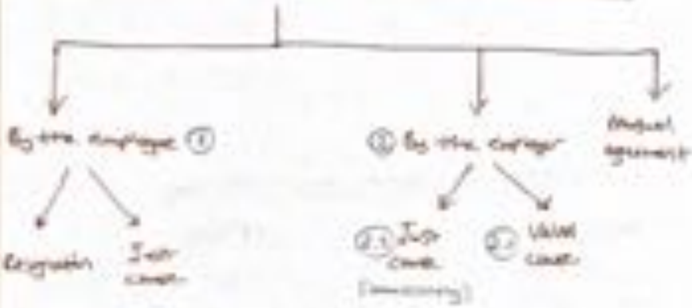
Excuse leave

- Marriage, death of close relative: [illegible] days
- [illegible] of [illegible]: 1 day

Maternity and [illegible] leave

- Maternity: 8 weeks before and after birth (increased for multiple pregnancies)
- Nursing: 1.5 hour daily until child turns one

Termination of Indefinite Employment Contracts



① [illegible] reasons

* Cases that do not comply with moral and good faith [illegible] and [illegible] [illegible] [illegible] [illegible] after [illegible] of contract
* Force majeure [illegible] [illegible] [illegible] [illegible] [illegible]

2.1 → Business/workplace [illegible] [illegible]
→ Employee [illegible]
→ Employer [illegible]

① → [illegible] [illegible]
→ Actions against moral and good faith principles
→ Competing [illegible]