01 Zero & One

Unit 11: Simulations

Programming & AI, 1st secondary (Introduction to ICT)



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11-1 Modeling

- **Model and modeling**: A **model** is a **simplified** representation of a phenomenon we want to study
- **Classifying models by characteristics**
  - **Static model:** does not change over time
  - **Dynamic model:** is influenced by changes over time, and has two kinds:
  - **Deterministic model:** no irregular behavior and **only one result**
  - **Probabilistic model:** includes irregular behavior and **the result is not a single outcome**
- **Classifying models by type of expression**
  - **Physical (scale) model:** a physical form of the object
  - **Diagrammatic model:** expressed with a diagram
  - **Mathematical model:** expressed with formulas or logical expressions
- **Steps of modeling**
  - **1) Define the purpose:** of the model clearly.
  - **2) Clarify the elements:** that make up the model and the relationships between them.
  - **3) Choose the representation method:** (physical, diagrammatic, mathematical).
  - Train map example: purpose = reach your destination and know the transfers, elements = stations and lines only, representation = a drawing with colored lines and symbols.

Model	A simplified representation of a target phenomenon.
Modeling	The process of creating models of events or phenomena.
Static model	A model that does not change over time.
Dynamic model	A model that is influenced by changes over time.
Deterministic model	A model with no irregular behavior that gives only one result.
Probabilistic model	A model with irregular behavior whose result is not a single outcome.
Physical model	A physical form of an object: enlarged, full-scale or reduced.
Diagrammatic model	A representation using a diagram, such as a flowchart or route map.
Mathematical model	A representation using mathematical formulas or logical expressions.

11-2 Simulations [1]

- **Ways of referencing cells**: **Relative reference:** when you copy the formula, the referenced cell **changes automatically**
- **What is a simulation?**: A **simulation** means **running a model and changing it** in order to **predict** a phenomenon or event
- **Water volume simulation**: When pouring water into an empty container: **Water volume = Water inflow rate × Elapsed time**.
- **Balance simulation with compound interest**

- **Compound interest method:** the interest earned is added to the balance and earns interest itself in the next period.
- **Interest = Current balance × Interest rate:** .
- **Next period's balance = Current balance + Interest:** .
- Example: 100 at 5% → year 1: 105, year 2: 110.25, year 3: about 115.76
- In the sheet: interest `=E3*$B$3` (the rate is absolute), and the new balance `=E3+F4`.

Relative reference	A reference whose referenced cell changes automatically when the formula is copied.
Absolute reference	A reference that keeps the row or column fixed, made with $.
Simulation	Manipulating a model in order to predict phenomena or events.
Compound interest method	A method where the interest is added to the principal for the next period.
Interest rate	The percentage used to calculate the interest for each period.
Principal	The starting amount before any interest is added.

11-3 Simulations [2]

- **Random numbers and RAND**: A **random number** is a number that can appear **with equal probability** anywhere within a certain range.
- **Two important functions**
  - **SUM(range1:range2):** adds the cells from the first to the second
  - **IF(logical_expression, value_if_true, value_if_false):** if the condition is true it shows the second value
  - Example: `=IF(A2>=70,"Pass","Fail")` shows Pass if the score is 70 or more, otherwise Fail.
- **The Monte Carlo method**: The **Monte Carlo method** solves problems by using **random numbers** in **probabilistic models**
- **Estimating π**
  - 1) With RAND, generate N points, each with X and Y between 0 and 1 (inside a square of side 1).
  - 2) A point is inside the **quarter circle** if `X^2+Y^2 <= 1`
  - 3) Count the points inside (n): quarter-circle area ÷ square area = π/4, so **π ≈ 4n/N**.
  - Example: 1,000 points with 785 inside → π ≈ 4 × 0.785 = 3.14.
  - The **more points** we use, the **higher the accuracy**, and the value gets closer to the real π.

Random number	A number that can appear with equal probability within a certain range.
RAND()	A spreadsheet function that generates a random number between 0 and 1.
SUM()	A spreadsheet function that adds the values in a range of cells.
IF()	A spreadsheet function that shows one value if a condition is true and another if it is false.
Monte Carlo method	Solving problems by using random numbers in probabilistic models.
Quadrant	A quarter of a circle; here the part where X and Y are both positive.

11-4 Queues

- **What is a queue?**: A **queue** is the line that forms when people wait for a service: a supermarket register, a ride at a theme park, a reception desk
- **Service start time**

- **Nobody at the register (no queue):** service start time = the customer's **arrival time**.
- **Someone before them (a queue):** service start time = the time **the previous customer finished** being served.

- **End time and waiting time**
  - **Service end time = Service start time + Service duration:** .
  - **Waiting time = Service start time − Arrival time:** .
  - Example (service takes 4 minutes): a customer arriving at 0 → starts at 0, ends at 4
- **Queue charts and queues in computers**: In a queue chart, the horizontal axis is the time in minutes since the first customer arrived, and the vertical axis is the number of customers

Queue	A line formed when customers wait for a service.
Arrival time	The moment a customer joins the queue.
Service start time	The arrival time if there is no queue, otherwise the time the previous customer finished.
Service duration	The time it takes to serve one customer.
Service end time	Service start time + service duration.
Waiting time	Service start time − arrival time.



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