UNIVERSITAS GADJAH MADA
FACULTY OF ENGINEERING
DEPARTEMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
CIVIL ENGINEERING, IUP PROGRAM

FINAL EXAMINATION

NUMERICAL METHOD

Even Semester Academic Year 2025/2026 | Monday, 15th June 2026 | 120 minutes

· Open-book examination, the use of computers **is not permitted**.
· Use the variable notation provided in the questions. The variable notation **is not always** x or y.
· Some variables have **units**

Problem 1. Ordinary Differential Equation (CP a1, a2, a3; weighting 34%)

One of the methods for predicting the population of an area in transportation planning is the logistic model, which is expressed by the following differential equation:

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right).$$

In the equation above, *P* represents the population, *t* represents time, *r* is the maximum growth rate when the population is still small (intrinsic growth rate), and *K* is the carrying capacity of the region.

A region is known to have a population of 7 million people in 2025, an intrinsic growth rate of 4%, and a regional carrying capacity of 14 million people.

Use the **third-order Runge-Kutta** method to predict the population of the region in 2035.

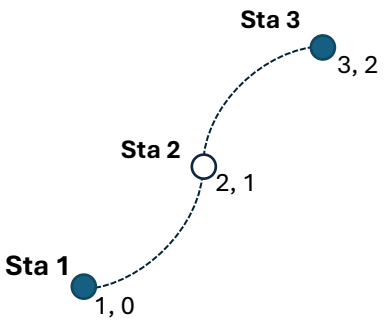
Use a calculation time step of Δt = 2 years

Problem 2. Numerical Interpolation (CP a1, a2, a3; weighting 33%)

A toll road alignment is planned through three station points (Sta) with the following coordinates:

Sta 1: (1, 0)
Sta 2: (2, 1)
Sta 3: (3, 2)

a. Develop an equation that connects Sta 1 and Sta 3 passing through Sta 2 as the toll road alignment using the Quadratic Spline method.



b. What modification is required if the derivatives of the curve slopes at both Sta 1 and Sta 3 are constrained to be zero, and what is the physical interpretation of this condition?

Problem 3. Numerical Integration (CP a1, a2, a3; weighting 33%)

A limestone hill will be partially excavated for tourism development. One of the cross-sections of the hill is provided in Table 1. The planned target excavation elevation is +370 m.

a. Calculate the volume of limestone excavated per meter length perpendicular to the cross-section, from x = 50m to x=170m. Use the Simpson's 1/3 method if possible. If it is not possible, use the Trapezoidal method and explain why Simpson's 1/3 method cannot be applied.

Table 1. Cross-section of the limestone hill.

Z (+m)	405	410	415	400	395	390	380	380	375	380	385	390	390
X (m)	50	60	70	80	90	100	110	120	130	140	150	160	170

Z (elevation), X (horizontal distance)

b. What are the advantages of using Simpson's 1/3 method compared with the Trapezoidal method, and when is the Trapezoidal method more advantageous than Simpson's method?

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