Answer questions 1, 2 and 3, and either questions 4 or 5.

**Question 1 (25 marks)**

The concept of a ‘learning curve’ reflects another way in which the marginal costs of a product decrease as we manufacture more. The learning curve is also known as the ‘experience curve’.

a) What is meant by the term ‘learning curve’? (4 marks)
b) Draw a graph depicting a number of learning curves for costs per unit vs number of units produced. (4 marks)
c) Explain what is meant by marginal cost. (4 marks)
d) Explain the difference between the ‘learning curve’ and ‘economies of scale’. (5 marks)
e) A School of Engineering within a University has a student racing car team. The time required for the team to assemble the first car is 100 hours. Their improvement (or learning rate is 0.8, which means that as output is doubled their time to assemble a car is reduced by 20%. Determine the time it will take the team to assemble the 10th car, and the total time required to assemble the first 10 cars. (8 marks)

Use the following expression for part (e):

\[ Z_u = K (n^n) \]

Where \( Z_u \) = the number of input resource units needed to produce output number \( u \)
\( K \) = the number of input resource units needed to produce the first output unit
\( u \) = the output unit number
\( n = \log S / \log 2 \) where \( S \) = the learning curve slope expressed as a decimal.

**Question 2 (25 marks)**

Three quantities form the basis for cost performance measurement using Earned Value Management. They are Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP).

a. Explain what is meant by EAC, BAC, BCWS, BCWP and ACWP? (5 marks)

b. Define the terms used on the following earned value analysis graph and explain what is happening to the project?
c. Define what is meant by, and give expressions for SV and CV.

Question 3 (25 marks)
A classic ‘transport demand/supply function’ will identify equilibrium points that represent a compromise between what users are willing to pay and what providers are willing to offer.

a) Sketch a representative graph for traffic against cost showing a demand curve and possible supply curves. Identify the equilibrium points and hence define an expression for elasticity. (10 marks)

b) Explain what is meant (use a graph) by ‘transport elasticity by activity’. (15 marks)
**Question 4 (25 marks)**

This question relates to the overall Atlantic Tunnel Project case study:

a. What are the economic drivers for the proposed project? (8 marks)
b. What are the Technical Performance Measures (TPMs) for the overall project? (8 marks)
c. What are the 5 top risks to the project and how will they be managed? (9 marks)

**Question 5 (25 marks)**

Major sub-divisions of the Atlantic Tunnel Project could be identified as the ‘physical tunnel’, the ‘train and control systems’, the ‘stations’, ‘utilities’ (eg, power supply and distribution, and tunnel vacuum provision), and ‘safety and rescue’. Choose one of these sub-divisions to answer the following three questions.

a) Describe the systems engineering approach to specification and design. (9 marks)
b) Describe the risks involved in the realisation. (8 marks)
c) Describe the business and engineering operational risks. (8 marks)