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THE UNIVERSITY of York

Degree Examination 2004

ENVIRONMENT DEPARTMENT

BSc in Environment, Economics and Ecology, Part 1a

QUANTITATIVE METHODS FOR ENVIRONMENTAL ECONOMICS AND MANAGEMENT

Time allowed: **one and a half hours**

Answer **ONE** question from **SECTION A** and **ONE** question from **SECTION B**

Standard University calculators, graph paper and statistical tables will be provided.

Pay adequate attention to spelling, punctuation and grammar, so that your answers can be readily understood

SECTION A

Question 1

The Environmental Protection Agency (EPA) is considering regulations that will require a reduction (r in billion tons) in SO_2 of 15 billion tons ($r = 15$) in an effort to mitigate the effects of acid rain on ecosystems. You are required to:

a) provide an estimate of the cost to the major utility companies ($C(r)$) of these new regulations (**25 marks**).

b) provide an estimate of the effects on jobs in the coal mining industry ($J(r)$) of these new regulations (**25 marks**).

You have the following data which show the annual cost to utilities $C(r)$ (billions) and the cost in jobs $J(r)$ (number of jobs lost) for 3 different reduction strategies:

Strategy	$r = 8$	$r = 10$	$r = 12$
Annual cost to utilities	£ 20.4	£34.5	£93.6
Cost in jobs	14,100	21,900	13,400

HINT: By ploting the annual cost to utilities with respect to r and the job loss to the coal mining industry with respect to r, you can infer that the best type of function that fits the data is a quadratic function both for $C(r)$ and $J(r)$.

Question 2

The cost of controlling SO_2 emissions at a firm increases rapidly as the amount of emissions reduced increases. Here is a possible model:

$$C(q) = 4,000 + 100q^2$$

where q is the reduction in emissions (in Kg of pollutant per day) and C is the daily cost (in UK-£) of this reduction.

a) If a firm is currently reducing its emission by 10 Kg each day, what is the marginal cost of reducing emissions even further? (**15 marks**)

b) Government clean-air subsidies to the firm are based on the formula

$$S(q) = 500q$$

where q is again the reduction in emissions and S is the subsidy (in UK-£). At what reduction level does the marginal cost become greater than the marginal subsidy? (**15 marks**)

c) Calculate the net cost function

$$N(q) = C(q) - S(q) \tag{1}$$

given the cost function and subsidy above and find the value of q that gives the lowest net cost and the corresponding (lowest) net cost. (**15 marks**)

d) Compare your answer to that in question b) and comment on your findings. (**5 marks**)

SECTION B

Question 3.

a) A national survey of 9000, 1 km^2 grid cells found that a total of 4500 grid squares contained at least one breeding pair of a particular species of bird. Of the grid squares with at least one breeding pair, 4000 grid squares are characterised as heather moorland. 2000 grid cells surveyed were characterised as heather moorland but had no breeding pairs recorded in them. From the set of records for the surveyed grid cells:

i. What is the probability of a grid cell containing at least one breeding bird pair? **[3 marks]**
ii. What is the probability of a grid cell being characterised as heather moorland? **[5 marks]**
iii What is the probability of a grid cell having at least one breeding pair given that the grid cell is characterised as heather moorland? **[7 marks]**

b) A sample of 40 peoples' annual salaries was taken. The value of each individual's salary in the sample is given below in thousands of dollars.

9.6	14.9	10.2	15.0	11.3	7.2	22.8	10.6	10.6	13.6	3.0
0.6	22.1	40.7	29.1	15.2	3.7	6.3	109.7	5.1	6.1	28.8
26.3	3.2	58.1	16.1	5.1	8.9	31.2	28.2	1.1	55.2	6.4
15.8	9.2	2.4	23.8	6.2	4.0	1.3				

i. On the graph paper provided, construct a histogram for the salary variable. **[6 marks]**
ii. Report the mean and the standard deviation of the variable. **[6 marks]**
iii. Construct a 95% confidence interval for the mean. **[7 marks]**
iv. Use the information given by the histogram, mean and standard deviation to comment on the shape, size, central tendency and dispersion of the salary variable. **[6 marks]**

c) If a population of a particular butterfly species has a wing span measurement that is normally distributed with a mean of 10 cm and standard deviation equal to 2 cm, what is the probability of randomly sampling a butterfly with a wing span measurement of between 6 and 11 cm? **[10 marks]**

Question 4.

a) If a pollution inspector is responsible for surveying the effluent outlets at 12 factories and the inspector is expected to inspect 3 factories per day:
   i. How many combinations of three factories can the inspector select from the 12 factories for one day visits? **[5 marks]**
   ii. How many permutations can make up these combinations? **[5 marks]**

b) The heights of a random sample of tree saplings (in cm) from a reforestation project have been measured and are presented below.

107.6	95.8	91.7	91.3	79.5	95.2	80.3	82.7	103.7	107.0	94.3	103.8
116.8	100.7	107.4	86.6	89.6	89.6	97.7	102.6				

   i. Produce a stem-and-leaf plot for the height variable. **[6 marks]**
   ii. Produce a boxplot for the variable. **[7 marks]**
   iii. Calculate mean and standard deviation of the variable. **[6 marks]**
   iv. Construct a 95% confidence interval for the mean of the sample. **[8 marks]**

c) A piece of equipment is developed that can detect if the pH of an effluent outflow from a factory is below or above a threshold level. The equipment is successful at correctly predicting what side of the threshold a sample lies in 80% of trials. If 10 trials of the equipment are made what is the probability that:
   i. 7 of the trials are successful? **[6 marks]**
   ii. Between 6 and 10, inclusive, of the trials are successful? **[7 marks]**