



**CERTIFIED PUBLIC ACCOUNTANT
FOUNDATION LEVEL 1 EXAMINATION**

**F1.1: BUSINESS MATHEMATICS AND QUANTITATIVE
METHODS.**

DATE: THURSDAY 29, AUGUST 2024

MARKING GUIDE & MODEL ANSWERS

QUESTION ONE

Marking guide

Criteria

Question	Description	Marks	Total Marks
a)	Benefit of samples (1 Mark each, Maximum 4)		4
b)	Disadvantage of random sampling (1 Mark each, Maximum 3)		3
c)	Median		
	Arranging the data in ascending or descend	1	
	Answer	1	2
d) i.	Mode		
	Formula	0.5	
	Calculation	0.5	1
d) ii.	Mean		
	Formula	0.5	
	Grouping	0.5	
	Calculation	0.5	
	Answer	0.5	2
e i)	Weighted mean		
	Calculations of weighted prices	1	
	Answer	1	2
ii)	Three types of kurtosis (0.5 Marks each, Maximum,3)	1.5	
	Explaining the types of kurtosis (0.5 Marks each, maximum,3)	1.5	
	Feature of normal distribution curve (1 mark each, maximum 4)	3	6
	Maximum marks		20

Model Answer

- a) **Reasons for using samples rather than the whole population at Musanze city**
- Saving on time (contacting everybody in entire population is time consuming)
 - Saving on money since less respondent are required.
 - It is convenient since the researcher takes data at his convent time.
 - Collection of richer data is enhanced since the researcher can choose to deal with professionals.
 - Samples are more manageable to use in research
- b) **Disadvantages of simple random sampling.**
- There is need for population listing.
 - It a time-consuming exercise.
 - There is down playing and over emphasizing of certain attributes.
 - There is complexity in analysing random variables

- v) Skills are needed

c) Ascending order (Getting median)

23	26	29	30	31	31	37	37
38	38	41	44	44	46	46	48
49	49	52	52	56	58	59	61
61	61	63	70	75	76	85	

Median $= (n+1) * 0.5 = (31+1) * 0.5 = 16$ th item

Therefore, median = 48.

d) i. Calculation of mode $= L + [(f1-f0)/(2f1-fo-f2) * h]$

$$= 40 + (8-7) / (2*8-7-8) * 10$$

$$= 42.5$$

Mode $= L + [(f1-f0)/(2f1-fo-f2) * h]$	
F1	8
F0	7
F2	5
H	10
L	40
MODE	42.5

ii. Calculation of arithmetic mean.

Scores	Midpoint(x)	Frequencies(f)	Fx
20-30	25	3	75
30-40	35	F0=7	245
40-50	45	F1=8	360
50-60	55	F2=5	275
60-70	65	4	260
70-80	75	3	225
80-90	85	1	85
Totals		31	1525

Mean = summation of fx / Summation of f = $1525/31 = 49.19$

e) i. Weighted mean

Items	Prices	Weight	Weighted price
Food	150	8	1200
Drink	130	6	780
Travel	200	5	1000
Research	120	2	240
Marketing	180	3	540
Totals		24	3760

Weighted mean= $3760/24=156.67$

ii. Kurtosis refers to the size of peakness of a distribution. Sometimes it may be necessary to distinguish measures of skewness and kurtosis from those corresponding to a population of which the sample was part. It becomes necessary to use their frequency curve. Kurtosis is the peakedness (quality of flatness) of a distribution relative to the mean. Frequency curves may have several different bell shapes. The most common are as follows

- Bell shaped normal curve: Bell shaped normal curve.
- **Mesokurtic:** This type of kurtosis describes a distribution with a shape similar to the normal distribution. A mesokurtic distribution has a kurtosis value of 0 when excess kurtosis is used (or 3 if the value is not adjusted for excess kurtosis). It has a moderate peak and tails that are neither too heavy nor too light.
- **Leptokurtic:** A leptokurtic distribution has a higher peak and heavier tails compared to the normal distribution. This type of distribution has positive excess kurtosis (greater than 0) and indicates that the data has more frequent extreme values (outliers). The distribution is more peaked around the mean and has fatter tails, suggesting that extreme values are more common.
- **Platykurtic:** A platykurtic distribution has a lower peak and lighter tails compared to the normal distribution. It has negative excess kurtosis (less than 0) and indicates fewer and less extreme outliers. The distribution is flatter around the mean and has thinner tails, suggesting that extreme values are less common.

Properties of a normal distribution curve

- It is bell shaped.
- The never touches the horizontal line.
- The Mean, mode and median are exactly same.
- Symmetrical about the mean. This means the number of units in the data below the mean is the same as the number of units above the mean.

- The height of the normal curve is maximum at the value of the mean. This means that the normal distribution has the same value for the mean, median and the mode located at the centre of the distribution.
- Normal distribution is unimodal (has only one mode).
- The curve is continuous, for each value of x , there is a corresponding value of y .
- The curve never touches the horizontal axis (asymptotic to the horizontal axis), that is, the height of the normal distribution curve declines as you move in either direction from the mean but never touches the base so that the tails of the curve on both sides extend indefinitely.
- The total area under the normal curve is approximately equal to 1 (100%).

QUESTION TWO

Marking guide

Criteria

Question	Description	Marks	Total Marks
a) i	Cost function		
	Formula	0.5	
	Calculation	2	
	Answer	0.5	3
ii	Revenue function		
	Formula	0.5	
	Calculation	2	
	Answer	0.5	3
b)	Price and quantity to maximize profit		
	Formula for profit	0.5	
	Price calculation	2	
	Answer	0.5	
	Formula for quantity	0.5	
	Quantity calculations	2	
	Answer	0.5	6
c)	Simultaneous equation		
	Formulation of the equations	1	
	Cost each scone calculations	1	
	Cost of each cup of coffee calculations	1	
	Answer for scones	0.5	
	Answer for a cup of coffee	0.5	4
d)	First and second derivatives		
i	First derivative function formulation (0.5 mark each, maximum 1)	1	
	Calculation	0.5	
	Answer	0.5	
ii	Second derivative function formulation (0.5 mark each, maximum 1)	1	

	Calculation	0.5	
	Answer	0.5	4
	Maximum marks		20

Model Answer

(a)

i. Total cost function can be obtained from expression of marginal cost (MC) since,
 $\frac{d(TC)}{dQ} = (MC)$ Then

$$dTC = (MC)dQ$$

Integrating both sides gives:

$$TC = \int (MC)dQ$$

$$\text{Given } MC = Q^2 - 28Q + 211$$

$$\text{then } TC = \int (Q^2 - 28Q + 211)dQ$$

$$TC = \frac{Q^3}{3} - \frac{28Q^2}{2} + 211Q + A$$

A – is a constant of integration.

Given that when $Q = 0$, $TC = \text{FRW}10$ million

$$\text{then } A = 10$$

So, the total cost function is as follows:

$$TC = \frac{Q^3}{3} - 14Q^2 + 211Q + 10,000,000$$

ii. The total revenue (TR) function can be obtained from Average revenue (AR) function as follows,

$$AR = \frac{TR}{Q} \text{ So } TR = Q \times AR$$

$$TR = Q \times (200 - 8Q)$$

$$TR = 200Q - 8Q^2$$

$$\text{b) Let profit} = z \quad P = 12 - 0.4Q \quad C = 5 + 4Q + 0.6Q^2$$

Profit $z = \text{revenue} - \text{Cost}$

$$Z = (12 - 0.4Q)Q - (5 + 4Q + 0.6Q^2)$$

$$Z = 12Q - 0.4Q^2 - 5 - 4Q - 0.6Q^2$$

$$Z = 8Q - Q^2 - 5$$

For maximum profit, the differentiation of z with respect to Q equals zero.

$$\frac{dz}{dQ} = 8 - 2Q = 0 \Rightarrow 2Q = 8 \Rightarrow Q = 4 \text{ units}$$

So, $P = 12 - 0.4Q$ and for $Q = 4$ units

$$= 12 - 1.6$$

$$= \text{FRW}10.4$$

$$\frac{d^2z}{dQ^2} = -2 < 0 \text{ Profit is maximized.}$$

Profit is maximized at a price of 10.4 and when quantity = 4 units

c) Let cost of scones = x

let cost of one cup of coffee = y

Elimination method

Ellie $3x + 2y = 22$

David $2x + 2y = 18$

$$X = 4$$

$$3 \cdot 4 + 2y = 22$$

$$12 + 2y = 22$$

$$2y = 22 - 12$$

$$2y = 10$$

$$Y = 5$$

Cost of scones FRW 4 and cost of one cup of coffee is FRW 5

Alternatively

Substitution method

Ellie $3x + 2y = 22$ (equation 1)

David $2x + 2y = 18$ (equation 2)

$$2y = -3x + 22$$

$$Y = -1.5x + 11$$

Substitute to the second equation

$$2x + 2(-1.5x + 11) = 18$$

$$2x-3x+22=18$$

$$-x=18-22$$

$$-x=-4$$

$$X=4$$

Substitute back to equation 1

$$3*4+2y=22$$

$$12+2y=22$$

$$2y=22-12$$

$$2y=10$$

$$Y=5$$

Cost of scones FRW 4 and cost of one cup of coffee is FRW 5

d) First order and second order derivatives

i) $10Q^2 - 30Q + 100$

First order

Let call the function P,

$$P = 10Q^2 - 30Q + 100$$

$$\frac{dP}{dQ} = 20Q - 30$$

Second

$$\frac{dP^2}{d^2q} = 20$$

ii) $8Q^3 - 10Q - 20,000$

First order

Let call the function P,

$$P = 8Q^3 - 10Q - 20,000$$

$$\frac{dP}{dQ} = 24Q^2 - 10$$

Second

$$\frac{dP^2}{d^2q} = 48Q$$

QUESTION THREE

Marking guide

Criteria

Question	Description	Marks	Total Marks
a)	Components of time series (1 Mark each, Maximum 2)		2
b)	Probability		
	Formula	0.5	
	Calculation	1.5	
	Answer from normal table	1	3
c)	Z SCORE		
	Formula	0.5	
	Calculation	1	
	Answer	1	
	formula	0.5	3
d) i	Standard error		
	Formula	0.5	
	Calculations	2	
	Answer	0.5	
ii	Benefits of standard error (1 Mark each, Maximum,3)	3	6
e)	Chi square test		
	Stating the null and alternative hypothesis	1	
	Preparing the table (calculations)	2	
	Degree of freedom	0.5	
	Confidence level	0.5	
	Answer	1	
	Decision	1	6
	Maximum answer		20

Model Answer

a) Components of time series

- Trend Component
- Seasonal Variation
- Cyclic Variation
- Irregular Variation

b) Probability that an applicant scored below 400 points

$$z = \frac{x - \mu}{\sigma}$$

where z is a z score or z value for probability, σ is standard deviation, μ is

the mean income and x is the requirement. $x = 400$, $\mu = 380$, $\sigma = 30$

$$P(z \leq \frac{400-380}{30})$$

$$P(z \leq 0.67) = 0.7486 \text{ or}$$

$$P(z \leq 0.66) = 0.7454$$

c) Z score

$$x = 77, \mu = 68, \sigma = 3$$

$$z = \frac{x-\mu}{\sigma} = \frac{77-68}{3} = 3$$

d) i) **Standard error of mean**

$$n = 750, \mu = 358, \sigma = 50$$

$$\text{Standard error} = \frac{\sigma}{\sqrt{n}} = \frac{50}{\sqrt{750}} = \frac{50}{\sqrt{27.39}} = 1.825$$

ii) Benefits of standard error

Assessment of Precision: The standard error quantifies the precision of a sample estimate. A smaller standard error indicates that the sample mean is likely to be closer to the population mean, thus reflecting higher precision in the estimate.

Confidence Intervals: The standard error is used to construct confidence intervals around sample estimates. By calculating confidence intervals, researchers can determine the range within which the true population parameter is likely to fall, with a specified level of confidence. This helps in making more informed conclusions about the population based on sample data.

Hypothesis Testing: In hypothesis testing, the standard error is used to compute test statistics, such as the t-statistic in t-tests. It helps in determining whether the observed differences or relationships in the data are statistically significant, aiding in decision-making about hypotheses.

Comparing Estimates: The standard error allows for the comparison of the variability of different sample estimates. By comparing the standard errors of different estimates or different groups, researchers can assess which estimates are more reliable or which groups show more consistent results.

e) **Chi square**

Details	Treated patients	Not treated patients	Total
Cured patients	60	80	140
Not cured patients	40	20	60
Total	100	100	200

Hypotheses

Null hypothesis, H_0 the drug is not effective in curing the disease

Alternative hypothesis, H_1 the drug is effective in curing the disease

Calculation of Expected frequencies

$$E_{11} = \frac{R_1 C_1}{n} = \frac{140 \times 100}{200} = 70$$

$$E_{12} = \frac{R_1 C_2}{n} = \frac{140 \times 100}{200} = 70$$

$$E_{21} = \frac{R_2 C_1}{n} = \frac{60 \times 100}{200} = 30$$

$$E_{22} = \frac{R_2 C_2}{n} = \frac{60 \times 100}{200} = 30$$

Calculation of chi square

Observed Frequency (O)	Expected Frequency (E)	$(O - E)^2$	$(O - E)^2/E$
60	70	100	1.429
80	70	100	1.429
40	30	100	3.333
20	30	100	3.333
			9.524

Calculated chi square is 9.524

Tabulated chi square is obtained from the degree of freedom and the significance level

Significance level is 5% from the confidence level of 95%

Degree of freedom is $V = (r - 1) (c - 1) = (2 - 1) (2 - 1) = 1$

Therefore, the tabulated chi square from the table is 3.841

Decision: The calculated value of χ^2 is greater than the tabulated value, the null hypothesis of independence is rejected. This means that the drug is effective in curing the disease.

QUESTION FOUR

Marking guide

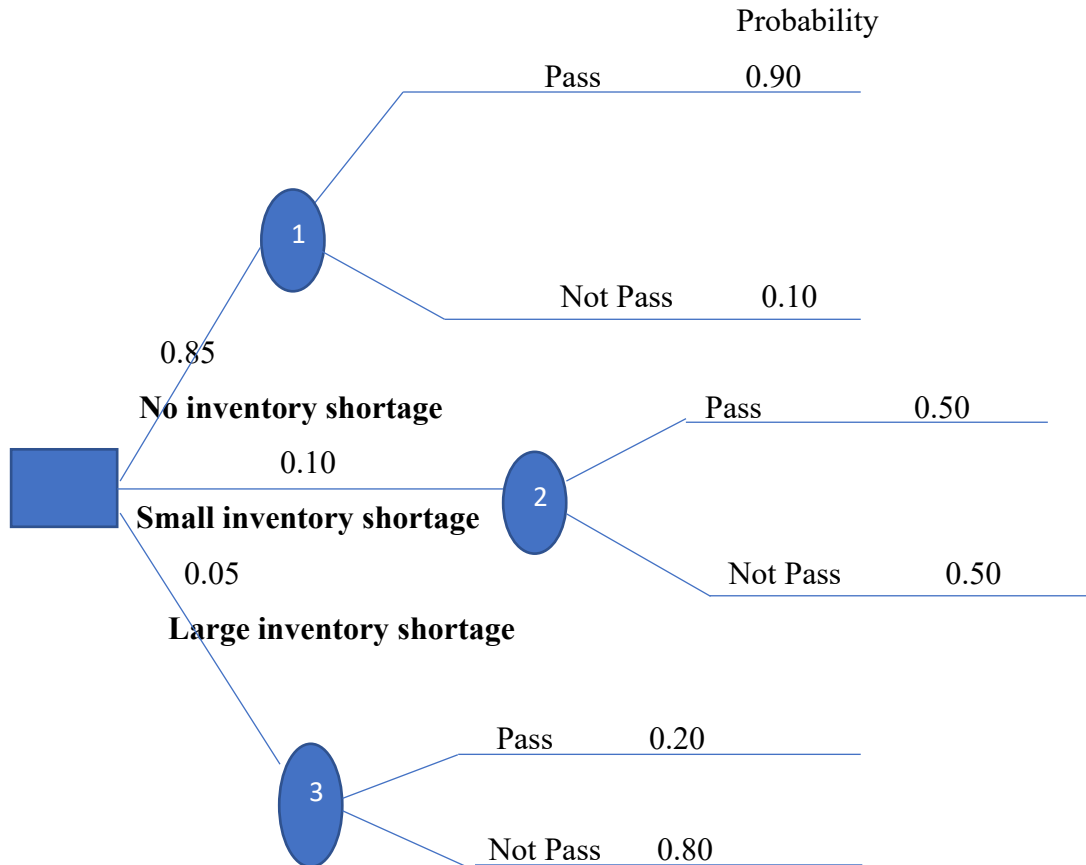
Criteria

Question	Description	Marks	Total Marks
a)	Drawing no short branches	1.5	
	Drawing for small branches	1.5	
	Drawing for large branches	1.5	
	Calculations and answer	1.5	6
b)	Random variable	1	
	Probability distribution	1	2
c)	Properties of binomial distribution (1 mark each, maximum 4 marks)		4
d)	Forecasting using linear regression		
	Totals for x	1	
	Totals for y	1	
	Totals for xy	1	
	Totals for x squared	1	
	Formula for a	0.5	
	Formula for b	1	
	Calculations for a	1	
	Calculations for b	1	
	Answer	0.5	8
	Maximum marks		20

Model Answer

(a) Probability of passing the test using probability tree

Probability Tree



Probability of passing the test = Probability of passing/no shortage + Probability of passing/small shortage + Probability of passing/large shortage.

$$\text{Probability of passing the test} = (0.85 \times 0.90) + (0.10 \times 0.50) + (0.05 \times 0.20) = 0.825$$

(b) Difference between random variable and probability distribution

A random variable is a variable whose values are determined by chance while probability distribution is a list of distinct numerical values of X along with their associated probabilities. Sometimes a formula can be used in place of a list.

Properties of random variables

- Definition: A discrete random variable is defined by a probability distribution that lists each possible outcome and the probability of obtaining that outcome. A continuous random variable is defined by its probability density function. To find the probability that $a \leq x \leq b$ for the continuous random variable x, find the area under its probability density p.
- Expected Value: The expected value of a random variable is the weighted average of its possible values. Each value is weighted by the probability that the outcome occurs.

- Independence: Two random variables x and y are independent if their joint density $r(x, y)$ factors into two one-dimensional densities: $r(x, y) = p(x)q(y)$.
- Variance: The variance of a random variable x is defined as $\text{Var}(x) = E(x - E(x))^2$.

(c) Properties of binomial probability distribution

- Fixed Number of Trials (n): There must be number of repeated identical trials, n .
- Two Possible Outcomes: Each trial results into two possible outcomes referred to as either success or failure.
- The trials are independent i.e. the outcome on one trial does not affect the outcome on the other trial.
- Constant Probability of Success (p): The probability of success on each trial is constant and denoted by p . Consequently, the probability of failure is $1 - p$. The constant probability ensures that each trial is identical in terms of the likelihood of success.
- The probability of success is the same on every trial.
- **Probability of k Successes:** The probability of observing exactly k successes in n trials is given by the binomial probability formula.

(d) Forecasting the cost for January 2024 using Linear regression equation method

Month	X	Cost, Y (FRW)	x^2	Xy
January	1	20	1	20
February	2	30	4	60
March	3	40	9	120
April	4	50	16	200
May	5	20	25	100
June	6	30	36	180
July	7	40	49	280
August	8	50	64	400
September	9	60	81	540
October	10	70	100	700
November	11	10	121	110
December	12	9	144	108
Total	78	429	650	2818

$$\Sigma x = 78, n = 12, \Sigma y = 429, \Sigma xy = 2818, \Sigma x^2 = 650$$

$y = a + bx$. Where; y = Dependent variable, a = intercept of y , b = Slope, x = Independent variable

$$b = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$$

$$b = \frac{(12 * 2818) - (78 * 429)}{(12 * 650) - (78)^2} = \frac{33,816 - 33,462}{7,800 - 6,084} = \frac{354}{1,716} = 0.206$$

$$a = \frac{\sum y - b \sum x}{n}$$

$$a = \frac{429 - 0.206 * 78}{12} = 34.411$$

$$Y = 34.411 + 0.206x$$

Cost for January 2024

x = 13, Y is Jan 2024

$$Y = 34.411 + 0.206(13)$$

$$Y = 37.089 \approx 37$$

The cost for January 2024 is FRW 37

QUESTION FIVE

Marking guide

Criteria

Question	Description	Marks	Total Marks
a)	Importance of network diagrams (1 mark each, maximum 2)		2
b)	Additive and multiplicative models (1 mark each)		2
c)	Amount for compound interest		
	Formula for annual	0.5	
	Calculations	1	
	Answer	0.5	
	Formula for quarterly	0.5	
	Calculations	1	
	Answer	0.5	
	Formula for semi quarterly	0.5	
	calculations	1	
	Answer	0.5	6
d)	Amount after one year		
	Formula	0.5	
	Calculation	1	
	Answer	0.5	2
e) i	Laspeyres price index (and Paasche's price index)		
	Summation of p_1q_0	0.5	
	Summation of p_0q_0	0.5	
	Summation of p_1q_1	0.5	
	Summation of p_0q_1	0.5	
	formula for Laspeyres price index	0.5	
	Formula for Paasches price index	0.5	
	Calculation for Laspeyres price index	0.5	
	Calculations for Paasches price index	0.5	
	Answers	1	5
ii	Simple price index		
	Calculation	0.5	
	Answer	0.5	1
iii	Fixed base	1	
	Chain based	1	2
	Maximum marks		20

Model Answer

(a) Importance of network diagram

- **Network Diagrams help justify your time estimate for the project.** Since network diagram of a project shows how activities are interrelated with each other from the beginning of the project till the end, it will be very beneficial for calculating the overall project duration. After the critical path of the project is determined, activities on the critical path will give us the total duration of the project respectively.
- **Network Diagrams aid in planning, organizing and controlling.** Since all project activities are shown in sequence with relevant interrelationships, the network diagram of a project will help the project manager and team during planning and organizing. Network diagram will be useful during project execution as well since it is a snapshot of the project activities tied with the dependencies.
- **Network diagrams show interdependencies of activities.** Since interdependencies of activities are visible in the network diagram, it will be easier to see which activity can start after which one, which activity depends on each other, predecessors and successors of each activity etc.
- **Network Diagrams show workflow of the project activities.** So the project team will know the sequence of activities. At a certain point in the project, it will be easier to see in the network diagram what has been accomplished and the remaining activities and their interdependencies with each other.
- **Network diagrams identify opportunities to compress the schedule.** You may need to shorten the duration of the remaining activities in a project. This can be because your project is behind schedule and in order to complete the project on time, you need to compress the schedule. In this case, since network diagrams show the order of the activities and durations, it will be easier to focus on how to compress the remaining activities in the project.
- **Network diagrams show project progress.** Since it shows the order of activities in a project and total path from the beginning of the project till the end, it is a good instrument for showing the project progress.

(b) Difference between multiplicative model and additive model

The multiplicative model takes the form, in which the relationship between components are expressed in the form, Time series (Y) = Trend (T) × Seasonal variation (S) × Cyclic variation (C) × Irregular variation (I) for period t. This form assumes components are related to each other and yet still allows for components to result from different basic causes.

While

The additive model assumes the values of Time series equals the sum of the four components at any period t.

Time series (Y) = Trend (T) + Seasonal variation (S) + Cyclic variation (C) + Irregular variation (I) for period t. By assuming that the components are additive we are in effect taking components to be independent of each other.

(c) Calculation of amount charged at the end of the period when interest is charged annually, quarterly and semi – annually.

Interest rate $i = 10\%$, Present value, $PV = \text{FRW } 2,000$, Time, $n = 2$, Future Value, $FV = ?$
 $m =$ numbers of compounding periods.

Annually

$$FV = PV(1+i)^n$$

$$FV = 2,000(1+0.10)^2$$

$$FV = \text{FRW } 2,420$$

Semi -annually

$$FV = PV(1+i/m)^{n*m}$$

$$FV = 2,000(1+0.10/2)^{2*2}$$

$$FV = \text{FRW } 2,431$$

Quarterly

$$FV = PV(1+i/m)^{n*m}$$

$$FV = 2,000(1+0.10/4)^{2*4}$$

$$FV = \text{FRW } 2,437$$

(d) Calculation of amount invested at the end of the first year

$$PV = \text{FRW } 4,000, n = 1, i = 10\%$$

$$FV = 4,000(1+0.10)^1 + 5,000 = \text{FRW } 9,400$$

(e) i) Calculation of Laspeyres piece index and Paasche's price index

Year		Commodity				Total	
		A	B	C	D		
2022	P0	4	3	2	5		
	Q0	20	15	25	12		
2023	P1	6	5	3	7		
	Q1	10	12	15	10		
	P0Q0	80	45	50	60		235
	P1Q0	120	75	75	84		354

	P0Q1	40	36	30	50	156
	P1Q1	60	60	45	70	235

Laspeyre's price index

$$\text{Laspeyre's price index} = \frac{\sum P_1 Q_0}{\sum P_0 Q_0} \times 100$$

$$\text{Laspeyre's price index} = \frac{354}{235} \times 100 = 150.638$$

Paasche's price index

$$\text{Paasche's price index} = \frac{\sum P_1 Q_1}{\sum P_0 Q_1} \times 100$$

$$\text{Paasche's price index} = \frac{235}{156} \times 100 = 150.641$$

ii) Calculation of simple price index

Current year price = FRW15,000 and Previous year price = FRW12,000

$$\text{Simple price index number} = \frac{\text{price of the commodity for the current year}}{\text{price of the commodity for the previous year}} \times 100$$

$$\text{Simple price index} = \frac{15,000}{12,000} \times 100 = 125$$

iii) Difference between fixed base and chain base index numbers

Fixed based method for constructing simplex index numbers uses the same base period hence the name fixed base. The method expresses the price of subsequent years as price relatives of the base year, given as, $\frac{P_c}{P_0} \times 100$ where P_c is the price in the current year (period), P_0 is the price index in the base year. When comparing prices of one item between two different periods of time.

While

Chain base method is a method for constructing simple index number that uses different base periods from year to year. This method shows whether the rate of change is rising, falling, or constant as well as the extent of change from year to year. The previous period (year) is usually taken as the base period for the subsequent period (year) when calculating the index.

QUESTION SIX

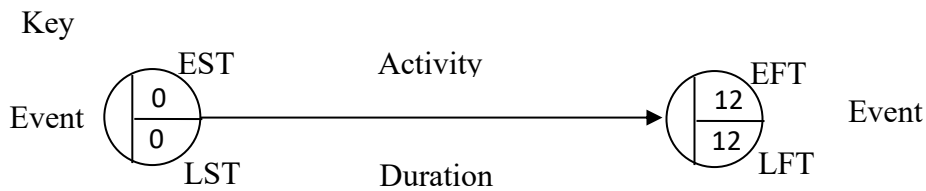
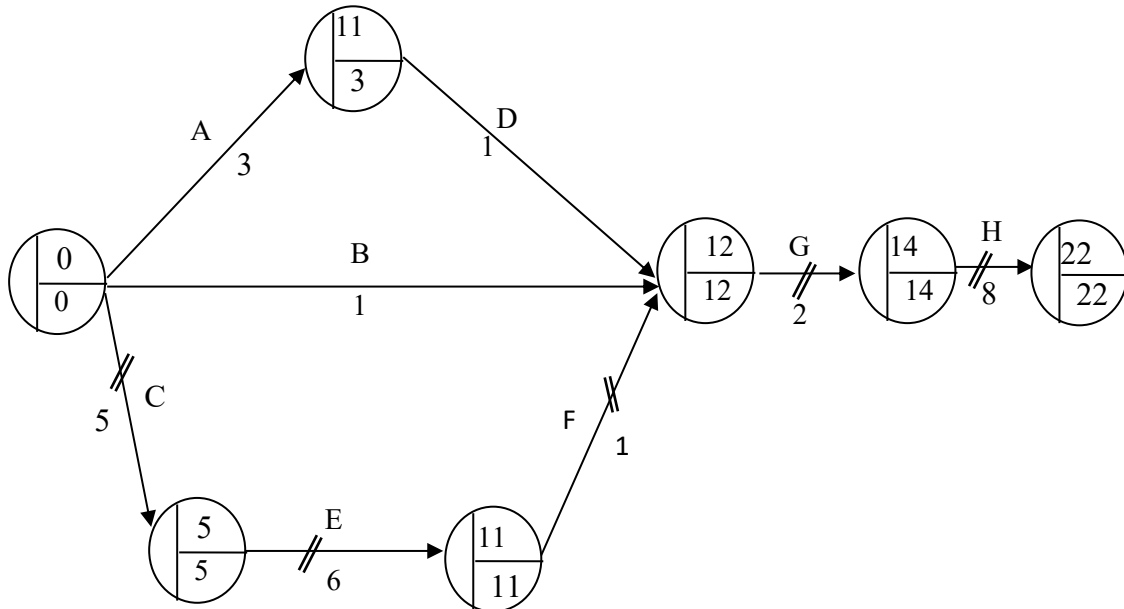
Marking guide

Criteria

Question	Description	Marks	Total Marks	
a) i	Drawing activity, A	1		
	Drawing activity, B	1		
	Drawing activity, C	1		
	Drawing activity, D	1		
	Drawing activity, E	1		
	Drawing activity, F	1		
	Drawing activity, G	1		
	Drawing activity, H	1		
	Answer	1	9	
ii	Latest finish time	1		
iii	Critical path	2	3	
b) i	Maxmin			
	Answer	0.5		
	Decision	0.5		
	ii	Maxmax		
	Answer	0.5		
	Decision	0.5		
	iii	Min max regret		
	Calculation	2		
	Decision	1		
	iv	Equally likely		
	Calculation	2		
	Decision	1	8	
	Maximum Marks		20	

QUESTION SIX.

a) Final network diagram is as follows. The project duration is 22 weeks.



EST means earliest start time

LST means latest start time

EFT means earliest end or finish time

LFT means latest finish time

ii) Latest finish time for demand analysis activity(H) is 22weeks

iii) The critical path is the longest path of a project decision which shows critical activities.C, E, F, G.H

b) Determine the optimal decision using:

i)Max-min criterion.

Decisions	Worst	
Expand	150	
Reduce	140	.
Do nothing	160	Choose this

The decision under Max-min criterion is to choose to do nothing because it has the maximum of the minimum payoff

ii)Max-max criterion.

Decisions	Best	.
Expand	250	Choose this
Reduce	180	
Do nothing	220	

The decision under Max-max criterion is to choose to expand because it has the maximum of the maximum payoff

iii)Min-max regret criterion.

Regret table

Decisions	High demand	Moderate demand	Little demand	maximum
Expand	220-150=70	225-225=0	250-250=0	70 choose expand
Reduce	220-180=40	225-140=85	250-180=70	85
Do nothing	220-220=0	225-210=15	250-160=90	90

The decision under Min-max criterion is to choose to expand because it has the minimum of the maximum payoff

iv) Maximum expected payoff (assuming equal likelihood of states of nature)

Expand; Expected payoff = $(150+225+250)/3 = 208.33$

Reduce; Expected payoff = $(180+140+180)/3 = 166.67$

Do nothing; Expected payoff = $(220+210+160)/3 = 196.67$

The decision under maximum expected payoff criterion is to expand because it has the maximum expected payoff of 208.33

QUESTION SEVEN

Marking guide

Criteria

Question	Description	Marks	Total Marks	
a)	Advantages of linear programming (1 mark each, maximum 4 marks)		4	
b)	Requirements of linear programming (1 mark each, maximum 4 marks)		4	
C)	i	Formulation of linear programming	1.5	
		Listing the non-negativity constraints	1.5	
		Formulation of $x+2y=10$	1.5	
		Formulation of $2x+y=13$	1.5	6
		ii	Drawing x axis	
		Drawing y axis		
		Formulation coordinates x, y for $x+2y=10$	1	
		Formulation coordinates for $2x+y=13$	1	
		Drawing linear equation for $x+2y=10$	1	
		Drawing linear equation for $x+2y=10$	1	
	Establishing the costs for points A and B	1		
	Choosing the answer for the minimum cost	1	6	
	Maximum marks		20	

a) Advantages of linear programming.

- i) Helps in finding optimal solutions
- ii) Helps to analyse economic and industrial patterns
- iii) Helps to improve management quality
- iv) Helps to improve flexibility in the organization.
- v) Help to solve complex business models
- vi) Helps to assign work to workers by assignment techniques
 - Helps in distribution of goods through transportation technique
 - Helps in providing better tools for adjustment to meet changing conditions.
 - Improves the quality of decisions. The manager who uses linear programming methods becomes more objective than subjective.

b) Requirements of linear programming.

- i) There must be an objective function for example profit maximization function
- ii) There must be constraints or limited resources

- iii There must be various and possible different causes of actions
- iv) Linearity that all problems can be expressed in linear equations.
- v) Non negativity constraints ($x, y \geq 0$)

(d)

- i.** Formulation of linear programming
- $(Z)=60x+80y$Objective function
- $x, y \geq 0$Non negativity
- $x+2y \geq 10$Vitamin B constraint
- $2x+y \geq 13$Vitamin C constraint

$x+2y=10$

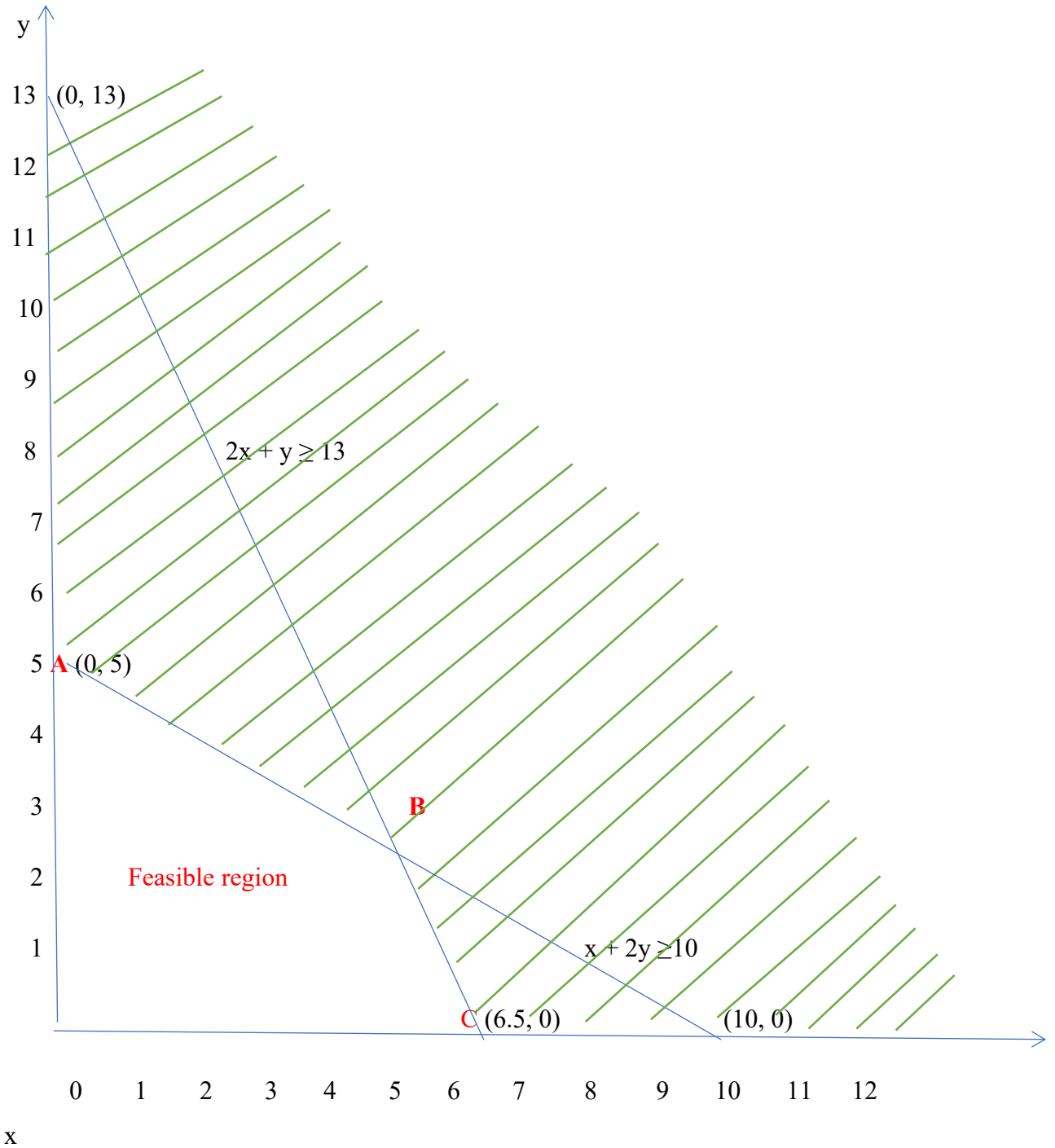
x	0	10
y	5	0

$2x+y=13$

x	0	6.5
y	13	0

ii. Graphical method

A graph of y against x



Feasible solution

Points	Coordinates	Objective Function, $C=60x+80y$
A	(0, 5)	FRW 400
B	(5.33, 2.33)	FRW 506.2
C	(6.5, 0)	FRW 390

Point B is an intersection of two equations $x + 2y = 10$ and $2x + y = 13$ and therefore the coordinates should be obtained by solving simultaneously.

$$x + 2y = 10 \dots\dots\dots (i)$$

$$2x + y = 13 \dots\dots\dots (ii)$$

Taking equation (i), using substitution we get $x = 10 - 2y$

Substitute $x = 10 - 2y$ into equation (ii) and get $y = 7/3 = 2.33$

Then by substituting $y = 7/3$ into equation (i), we will obtain $16/3 = 5.33$

The optimal solution is (6.5, 0) and the minimum cost is FRW 390.