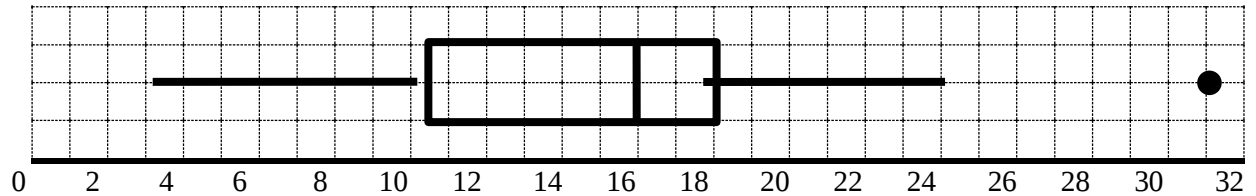


(b)



Min, Q1, Median, Q3

A1

Whisker end (24.5), outlier

A1

(c) In the first quartile (whisker to the left), as the value (5.4) lies between 3.6 and 10.5.

A1

Q3

(a) (Approximately) symmetrical.

A1

(b) There is a negative association between average income and road fatality rates – i.e. as income rises, fatality rate falls.

A1

The median for low income is approximately 25, whereas for medium income it is approximately 18 and for high income it is approximately 7.

A1

(Note that **three (3)** values MUST be quoted)

Q4

(a) Strong, negative, linear

A1

(b) $Fatality\ rate = 9.24 - 0.265 \times year\ number$

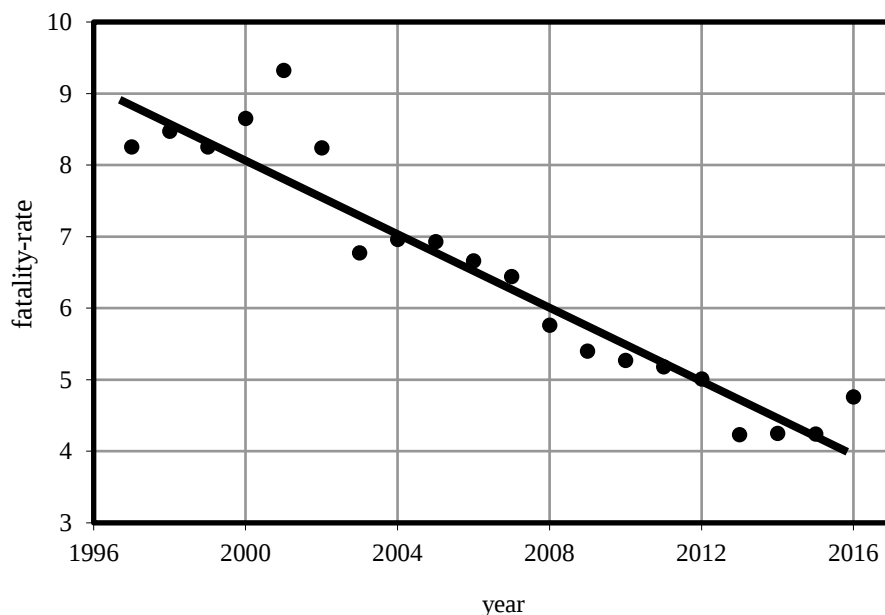
A1

(c) Correct calculations for two points MUST be shown

For example :

$$fatality\ rate\ (1996) = 9.24 - 0.265 \times 0 = 9.24$$

$$fatality\ rate\ (2016) = 9.24 - 0.265 \times 20 = 3.94$$



correct line

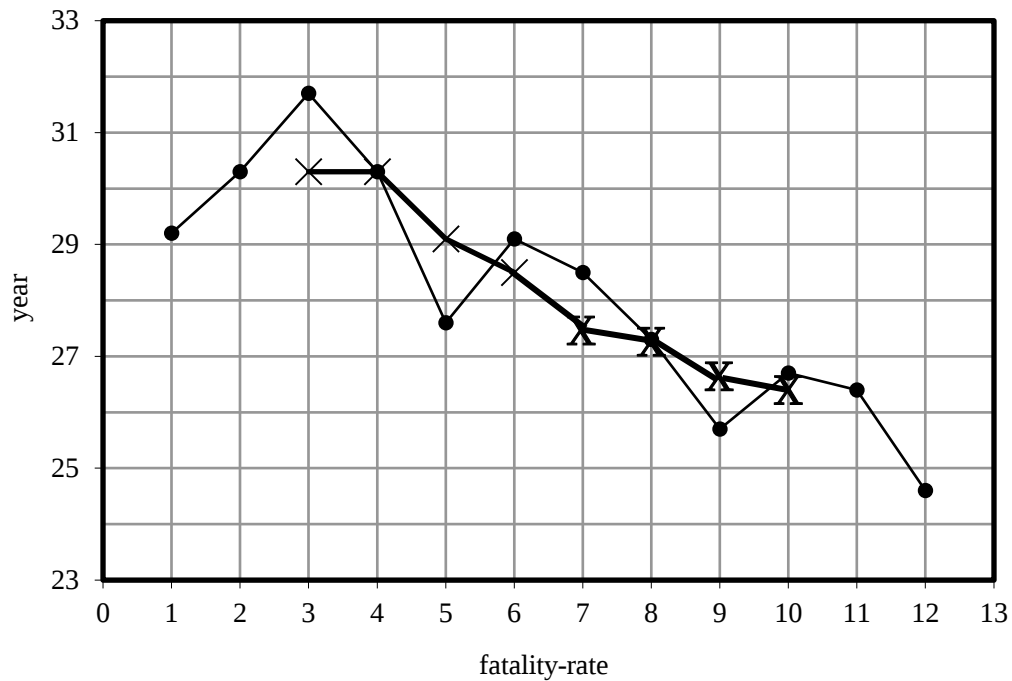
H1

(d) The *fatality rate* DECREASES by 0.265 for each 1 increase in the *year* value.

A1

- (e) $\text{fatality rate (1994)} = 9.24 - 0.265 \times (-2) = 9.77$ A1
- (f) $\text{Residual} = \text{actual} - \text{predicted} = 8.45 - 9.77 = -1.32$ A1
- (g) The actual *fatality rate* was LOWER than that predicted by the model. A1
- (h) Prediction is an extrapolation (outside the range used to construct the regression equation). A1

Q5



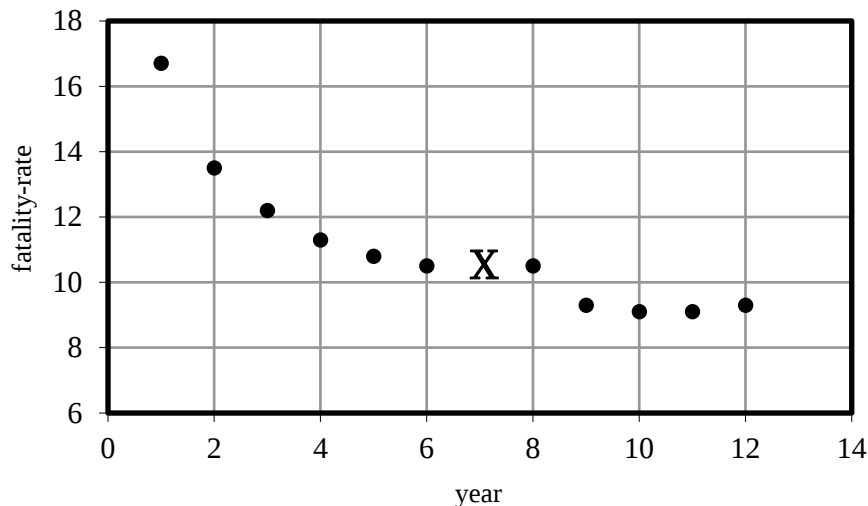
ALL FOUR two points correctly placed

A1

Q6

- (a) $\frac{1}{\text{fatality rate}} = 0.067 + 0.004 \times \text{time}$ 0.067 A1
- + 0.004 A1
- (b) $\frac{1}{\text{fatality rate}} = 0.067 + 0.004 \times 7$
- $\text{fatality rate} = \frac{1}{0.067 + 0.004 \times 7} = 10.5$ A1

(c)



Correctly plot the value calculated in (b)

H

Core – Recursion & Financial Modelling**Q7**(a) 3.5% A1

(b) $H_1 = 1.035 \times 22\,000 = \$22\,770$
 $H_2 = 1.035 \times 22\,770 = \$23\,566.95$
 OR $H_2 = 1.035 \times 1.035 \times 22\,000 = \$23\,566.95$ A1

(c) $H_n = \left(\dots\dots\dots 1.035 \dots\dots\dots \right)^n \times \left(\dots\dots\dots 22\,000 \dots\dots\dots \right)$ A1

(d) SOLVE($30\,000 = 1.035^N \times 22\,000$, N) gives $N = 9.0157\dots \approx 10$ years A1
 OR Carefully repeated manual recursion

8	28 969.80	9	29 983.74	10	31 033.17
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(e) Using Finance Solver
 $I\% = 3.5$, $PV = -22000$, $Pmt = 0$, $FV = 30000$, $PpY = 12$, $CpY = 12$
 Solve for N, $N = 106.493\dots \approx 107$ months
 OR
 SOLVE($30\,000 = (1 + 3.5/1200)^N \times 22\,000$, N) gives $N = 106.493\dots \approx 107$ months
 $120 - 107 = 13$ months sooner A1

(f) Using the calculator app/function
 Effective interest = $\text{eff}(3.5, 12) = 3.556\dots \approx 3.56\%$ A1

Q8

(a) Interest-only payment = $\frac{4.2 \times 370000}{100 \times 12} = \1295.00 A1

(b) Using Finance Solver
 $N = 276$, $I\% = 4.2$, $PV = 370000$, $FV = 0$, $PpY = 12$, $CpY = 12$
 Solve for Pmt, $Pmt = 2092.9119\dots \approx \2092.91 A1

- (c) Using Finance Solver
 $N = 300$, $I\% = 4.2$, $PV = 370000$, $FV = 0$, $PpY = 12$, $CpY = 12$
Solve for Pmt, $Pmt = 1994.0865\dots \approx \1994.09 A1
- (d) With interest-only option, total repaid = $\$1295.00 \times 24 + \$2092.91 \times 276 = \$608\,723.16$ A1
Repay loan plus interest, total repaid = $\$1994.09 \times 300 = \$598\,227.00$
Difference = $\$608\,723.16 - \$598\,227.00 = \$10\,496.16 \approx \$10\,500$ A1
- (e) The interest only period means that the balance remains at \$370 000 until the end of 2 years whereas paying some principal reduces the balance over this period. As compound interest is calculated on the current balance and this remains higher under the interest only arrangement, the overall interest is greater. A1

SECTION B : MODULES**Module 1 – Matrices****Q1**

(a) 1×3 A1

(b) $R = C \times M = \begin{bmatrix} 1050 & 350 & 675 \end{bmatrix} \times \begin{bmatrix} 1 \\ 4 \\ 7 \end{bmatrix} = \begin{bmatrix} 1050 \times 1 + 350 \times 4 + 675 \times 7 \end{bmatrix} = \begin{bmatrix} 7175 \end{bmatrix}.$

Full correct calculation shown
Correct answer

M1
A1

(c) $R = C \times M = \begin{bmatrix} 1050 & 350 & 675 \end{bmatrix} \times \begin{bmatrix} 4 \\ 1 \\ 7 \end{bmatrix} = \begin{bmatrix} 9275 \end{bmatrix}.$ A1

Q2

(a) $A \vee C$ and $B \vee D.$ A1

(b) Barry's team (B) A1

(c) If Chris' team and Barry's team win their games, then

$$D1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix}, D2 = \begin{bmatrix} 0 & 0 & 1 & 1 \\ 2 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}, D1 + D2 = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 2 & 0 & 1 & 2 \\ 2 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 \end{bmatrix} = \begin{matrix} 3 & A \\ 5 & B \\ 4 & C \\ 2 & D \end{matrix}$$
 A1

Q3

(a) $S_1 = \begin{bmatrix} 23 \\ 19 \\ 36 \\ 42 \end{bmatrix}$ A1

(b) $0.10 \times 20 + 0.10 \times 20 + 0.70 \times 40 + 0.10 \times 40 = 2 + 2 + 28 + 4 = 36$ A1

(c) Calculating $T^n S_0$ for large n , say $n = 30$ gives $\begin{bmatrix} 27 \\ 17 \\ 30 \\ 47 \end{bmatrix} \begin{matrix} B \\ G \\ R \\ Y \end{matrix}$ rounded to nearest integer, showing

Yellow will be the most popular colour.

A1

Q4

$$P_{2017} = \begin{bmatrix} 0.55 & 0.05 & 0.05 & 0.05 \\ 0.15 & 0.65 & 0.10 & 0.05 \\ 0.10 & 0.15 & 0.65 & 0.20 \\ 0.20 & 0.15 & 0.20 & 0.70 \end{bmatrix} \times \begin{bmatrix} 140 \\ 160 \\ 160 \\ 200 \end{bmatrix} + \begin{bmatrix} 20 \\ 25 \\ 25 \\ 40 \end{bmatrix} = \begin{bmatrix} 123 \\ 176 \\ 207 \\ 264 \end{bmatrix}$$
 A1

$$P_{2018} = \begin{bmatrix} 0.55 & 0.05 & 0.05 & 0.05 \\ 0.15 & 0.65 & 0.10 & 0.05 \\ 0.10 & 0.15 & 0.65 & 0.20 \\ 0.20 & 0.15 & 0.20 & 0.70 \end{bmatrix} \times \begin{bmatrix} 123 \\ 176 \\ 207 \\ 264 \end{bmatrix} + \begin{bmatrix} 20 \\ 25 \\ 25 \\ 40 \end{bmatrix} = \begin{bmatrix} 120 \\ 191.75 \\ 251.05 \\ 317.2 \end{bmatrix}$$

317 litres of Yellow paint will be required in 2018

A1

Module 2 – Networks and decision mathematics**Q1**

- (a) TGHSNRT, TRNSHGT (other answers possible) A1
- (b) Hamiltonian Cycle A1
- (c) He needs an Eulerian circuit or path and neither of these is possible in a network with more than 2 odd degree vertices. This network has four intersections of odd degree, H, R, N and T. A1

Q2

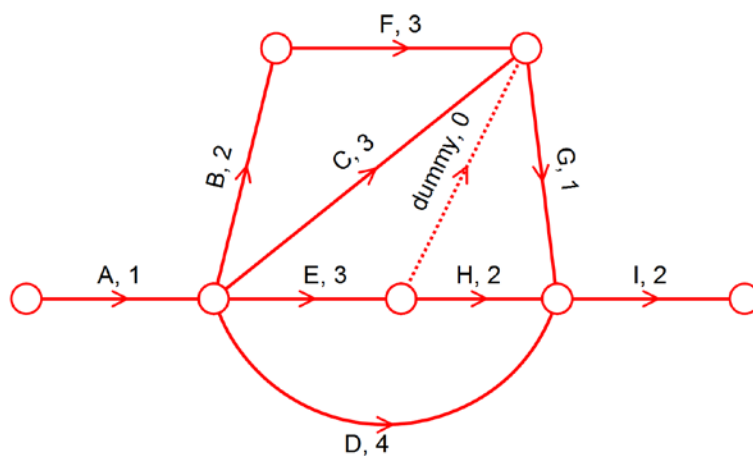
- (a) The zeros in this matrix can be covered with only three lines, it will only be ready for allocation when the minimum number of lines to cover the zeros is equal to the number of people and tasks i.e. four. A1

- (b)
- | | R | L | P | W |
|---|---|---|---|---|
| A | 0 | 3 | 2 | 1 |
| B | 2 | 4 | 2 | 0 |
| C | 0 | 0 | 0 | 2 |
| D | 1 | 1 | 0 | 0 |
- OR
- | | R | L | P | W |
|---|---|---|---|---|
| A | 0 | 2 | 1 | 0 |
| B | 3 | 4 | 2 | 0 |
| C | 1 | 0 | 0 | 2 |
| D | 2 | 1 | 0 | 0 |
- A1

- (c) Alf registrations, Barbara roadworthiness certificates, Clarice licences and Donald learner's permits. A1

Q3

- (a) C and F. A1
- (b) 9 hours A1
- (c) 2 hours A1
- (d) 8 hours. New critical path is AEHI with a length of 8 hours. A1
- (e)



A1

- (f) C, G and D. A1

Module 3 – Geometry & Measurement**Q1**

(a) Radius sphere = $120 \div 2 = 60 \text{ mm} = 6.0 \text{ cm}$

$$\text{Volume} = \frac{4}{3} \times \pi \times 6.0^3 = 904.778... \approx 905 \text{ cm}^3 \quad \text{A1}$$

(b) Density = $\frac{7260}{905} = 8.0220... \approx 8.02 \text{ g/cm}^3 \quad \text{A1}$

(c) $8.00 = \frac{4000}{\text{volume}}$, giving volume = $\frac{4000}{8} = 500 \text{ cm}^3 \quad \text{A1}$

$$500 = \frac{4}{3} \times \pi \times r^3, \text{ giving } r = \sqrt[3]{\frac{3 \times 5000}{4 \times \pi}} = 4.923...$$

Diameter = $2 \times 4.923 = 9.846 \approx 9.8 \text{ cm} \quad \text{A1}$

Q2

(a) Distance = $6400 \times 2 \times \pi \times \frac{(55+2)}{360} = 6366.9611... \approx 6367 \text{ km} \quad \text{A1}$

Note that the angles are added since one place is north of the equator and the other is south.

(b) Since Melbourne is to the east of Nairobi, its time will be AHEAD.
So, ADD seven hours to 8.30 pm to give 3.30 am Saturday morning. A1

(c) Radius small circle = $6400 \cos 34^\circ = 5305.84 \approx 5306 \text{ km}$
Difference in longitude = $151^\circ - 18^\circ = 133^\circ$ M1

Arc distance = $\frac{5306 \times \pi}{180} \times 133 = 12\,316.75... \approx 12\,320 \text{ km} \quad \text{A1}$

Q3

(a) Michael, the official and the competitor form a right-angled triangle.
From the competitor, the angle between the official and Michael can be found from

$$\cos\left(\frac{23.0}{30.0}\right) = 39.9445...^\circ \quad \text{A1}$$

The bearing of Michael is therefore $90^\circ - 39.9445 = 50.0555 \approx 050^\circ \quad \text{A1}$

(b) Radius of circle = $2.135 \div 2 = 1.0675 \text{ m}$
Use the cosine rule to find the angle at the centre, with the sides being
1.0675 m, 1.0675 m and 1.20 m (opposite the angle) M1

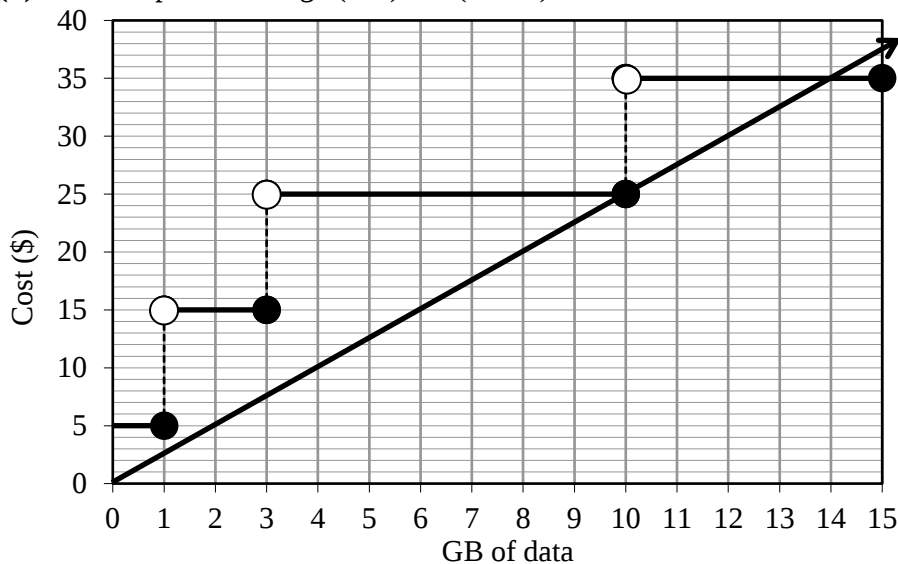
$$\text{Angle } POQ = \cos^{-1}\left(\frac{1.0675^2 + 1.0675^2 - 1.20^2}{2 \times 1.0675 \times 1.0675}\right) = 68.396884... \approx 68.40^\circ \quad \text{A1}$$

Module 4 – Graphs and Relations**Q1**

(a) \$25 A1

(b) $e = 25, f = 3, g = 10$ A1(c) $C = 2.5d, d \geq 0$ A1

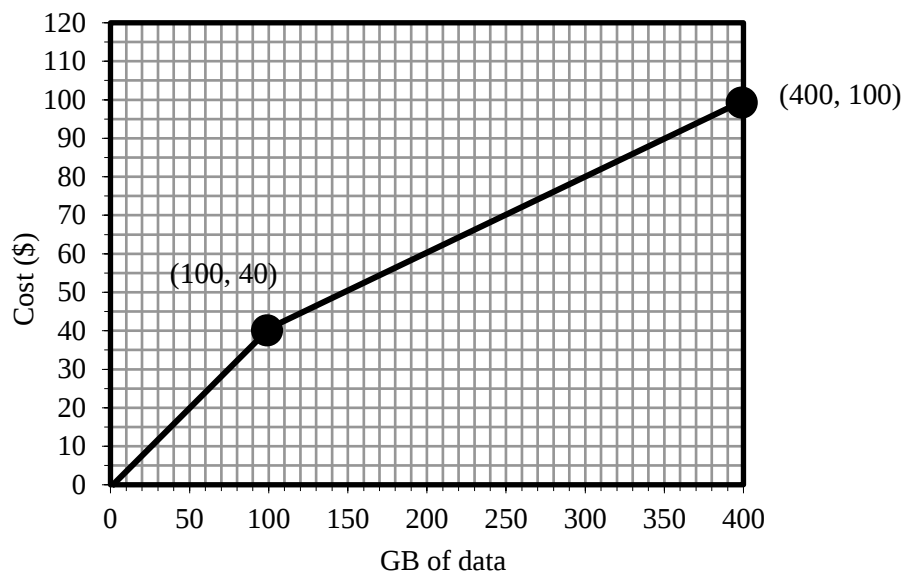
(d) Line passes through (0, 0) and (10, 25) A1



(e) It would be less expensive at any time unless Bill used exactly 10 GB or 14 GB of data at which times it would be the same or if Bill used more than 14 GB of data, at which time the step plan is cheaper. A1

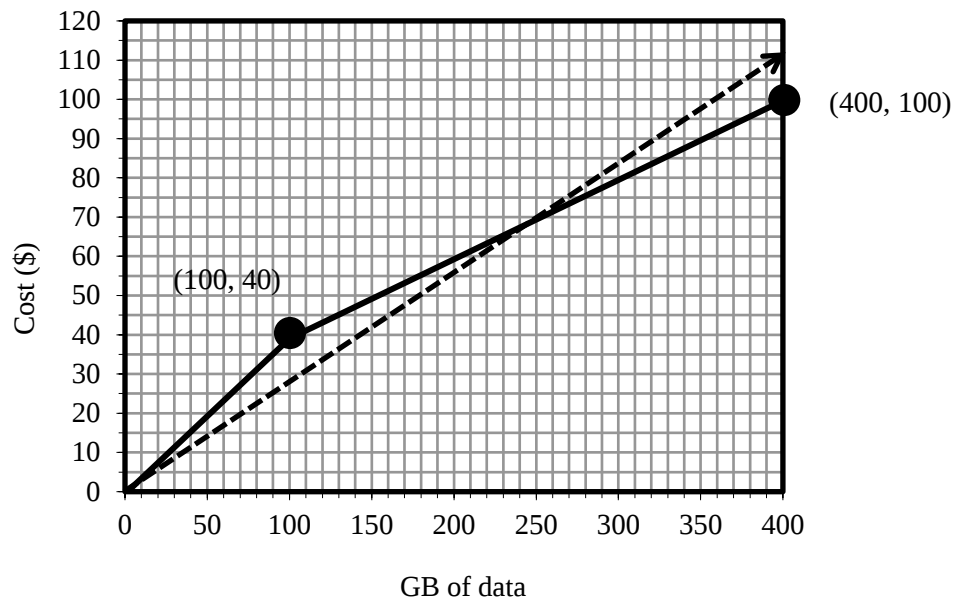
Q2 Line to point (100, 40) A1

Line to point (400, 100) A1

(b) $j = 0.2, k = 20$ A1

(c) $P = \begin{cases} -0.12d, & 0 < d \leq 100 \\ 0.08d - 20 & 100 < d \leq 400 \end{cases}$ A1

(d) More than 250 GB. (Line for $R = 0.28d$ is shown dashed) A1



OR (Algebraically)

Revenue = Cost

$$0.28d = 0.2d + 20$$

$$0.08d = 20$$

$$d = 20/0.08 = 250$$

Q3 $-1 < \text{gradient} < -\frac{1}{2}$

lower limit (- 1) A1

upper limit $\left(-\frac{1}{2}\right)$ A1

END OF SOLUTIONS