

| Question | Scheme | Marks | AOs |
|----------|---|------------|--------------|
| 2(a)(i) | $x / C =$ number of Construction students $y / D =$ number of Design students $z / H =$ number of Hospitality students | B1 | 3.3 |
| (ii) | The increase in number of students in 2020 $1110 \times 0.0027 \{= 2.997 \approx 3\}$ Or The number of students in 2020 $1110 \times 1.0027 = \{1112.997 \approx 1113\}$ | M1 | 1.1b |
| | $x + y + z = 1110$ $C + D + H = 1110$ $x - z = 370$ o.e. $C - H = 370$ o.e. $0.0125C + 0.025D - 0.02H = 3$ or 2.997 o.e. $1.0125C + 1.025D + 0.98H = 1113$ or 1112.997 o.e. $0.0125x + 0.025y - 0.02z = 3$ or 2.997 o.e. $1.0125x + 1.025y + 0.98z = 1113$ or 1112.997 o.e. | M1 A1 | 3.3 1.1b |
| | | (4) | |
| (b) | $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 1.0125 & 1.025 & 0.98 \end{pmatrix} \begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} 1110 \\ 370 \\ 1113 \end{pmatrix}$ or $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 0.0125 & 0.025 & -0.02 \end{pmatrix} \begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} 1110 \\ 370 \\ 3 \end{pmatrix}$ | M1 A1ft | 1.1b 1.1b |
| | $\begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 1.0125 & 1.025 & 0.98 \end{pmatrix}^{-1} \begin{pmatrix} 1110 \\ 370 \\ 1113 \end{pmatrix} = \begin{pmatrix} \dots \\ \dots \\ \dots \end{pmatrix}$ or $\begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 0.0125 & 0.025 & -0.02 \end{pmatrix}^{-1} \begin{pmatrix} 1110 \\ 370 \\ 3 \end{pmatrix} = \begin{pmatrix} \dots \\ \dots \\ \dots \end{pmatrix}$ | dM1 | 1.1b |
| | So in 2019, 720 students studied Construction , 40 students studied Design and 350 students studied Hospitality | A1 | 3.2a |
| | | (4) | |

(8 marks)

Notes:

Mark (i) and (ii) together

(a)(i)

B1: Defines 3 variables, minimum e.g. construction = C , Design = D , Hospitality = H . This may be seen in text of the question, abbreviations may be used

(ii)

M1: Finds either the increase or the number of students in 2020. This may be implied by any equation which equals 1113 or 1112.997. If students use 1100 instead of 1110 this is slip and we can award this mark.

M1: Attempts to use the model to set up at least 2 equations

A1: All 3 simplified equations correct (decimals or fractions), one for each different piece of information. Award with mark even if B0 is scored and it is clear what the variables used stand for.

Ignore any additional equations even if incorrect. As soon as 3 correct equations are seen you may award this mark.

Alternative approach

(i) **B1:** Construction = $H + 370$, Design = D , Hospitality = H

(ii) **M1M1A1:** $H + 370 + D + H = 1110$ o.e $C = H + 370$ $1.0125(H + 370) + 1.025D + 0.98H = 1113$ or 1112.997 o.e. they do not need to be simplified

(b) **This is M1 M1 A1 A1 on ePen but is marked M1A1M1A1**

M1: Uses their equation in part(a) to set up a matrix equation of the form $\begin{pmatrix} \dots & \dots & \dots \\ \dots & \dots & \dots \\ \dots & \dots & \dots \end{pmatrix} \begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} \dots \\ \dots \\ \dots \end{pmatrix}$, where "...” are numerical values.

A1ft: Correct matrix equation for their equations

dM1: Dependent on previous method mark. Writes $\left(\text{their } A \right)^{-1} \begin{pmatrix} 1110 \\ \text{their "370"} \\ \text{their "3"} \end{pmatrix}$ and obtains at

least one value of C , D or H . The inverse matrix need not be found, writing $A^{-1} \begin{pmatrix} 1110 \\ 370 \\ \text{their "3"} \end{pmatrix} = \dots$ is sufficient. A correct matrix equation followed by correct values implies this mark.

Condone $\begin{pmatrix} 1110 \\ \text{their "370"} \\ \text{their "3"} \end{pmatrix} A^{-1} = \dots$ as long as they reach some values. The values imply the correct method

Note: $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 0.0125 & 0.025 & -0.02 \end{pmatrix}^{-1} = \begin{pmatrix} \frac{10}{23} = 0.43\dots & \frac{18}{23} = 0.78\dots & -\frac{400}{23} = -17.39\dots \\ \frac{3}{23} = 0.13\dots & -\frac{13}{23} = -0.56\dots & \frac{800}{23} = 34.78\dots \\ \frac{10}{23} = 0.43\dots & -\frac{5}{23} = -0.21\dots & -\frac{400}{23} = -17.39\dots \end{pmatrix}$

$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 0 & -1 \\ 1.0125 & 1.025 & 0.98 \end{pmatrix}^{-1} = \begin{pmatrix} \frac{410}{23} = 17.82\dots & \frac{18}{23} = 0.78\dots & -\frac{400}{23} = -17.39\dots \\ -\frac{797}{23} = -34.65\dots & -\frac{13}{23} = -0.56\dots & \frac{800}{23} = 34.78\dots \\ \frac{410}{23} = 17.82\dots & -\frac{5}{23} = -0.21\dots & -\frac{400}{23} = -17.39\dots \end{pmatrix}$

A1: Interprets the answer in the context of the question, minimum is $C = 720$, $D = 40$, $H = 350$ with their variables. Condone the variable not been defined for this mark if it is clear which variable belong to what course.

Note: they must be using a matrix equation to solve the equation to score any marks.

Alternative approach

For example

Equations simplifies to $C - H = 370$, $D + 2H = 740$ and $1.025D + 1.9925H = 738.375$

$$\text{which leads to } \begin{pmatrix} 0 & 1 & 2 \\ 1 & 0 & -1 \\ 0 & 1.025 & 1.9925 \end{pmatrix} \begin{pmatrix} C \\ D \\ H \end{pmatrix} = \begin{pmatrix} 740 \\ 370 \\ 738.375 \end{pmatrix} \text{ then } \begin{pmatrix} C \\ D \\ H \end{pmatrix} =$$
$$\begin{pmatrix} 17.826 & 1 & -17.3913 \\ -34.6521 & 0 & 34.7826 \\ 17.826 & 0 & -17.3913 \end{pmatrix} \begin{pmatrix} 740 \\ 370 \\ 738.375 \end{pmatrix} = \begin{pmatrix} 720 \\ 40 \\ 350 \end{pmatrix}$$

Note: A 2 x 2 matrix is fine if it is appropriate for their equation.

Special Case: Forming an equation in one variable

(a)(i) B1: Hospitality = x , Construction = $x + 370$, Design = $740 - 2x$

(ii) M1M1A1: $1.0125(x + 370) + 1.025(740 - 2x) + 0.98x = 1113$ or 1112.997

(a)(i) B1: Hospitality = $x - 370$, Construction = x , Design = $1480 - 2x$

(ii) M1M1A1: $1.0125(x) + 1.025(1480 - 2x) + 0.98(x - 370) = 1113$ or 1112.997

(b) M0A0M0A0: They have an equation and are not forming and solving a matrix equation