Higher National Certificate/Diploma Assessment

Qualification	**Pearson BTEC Higher Nationals for England (2024)**
Unit number and title	**4002. Engineering Mathematics**
Assignment title	**Mathematical Methods and Statistical Techniques**
Assessor	**Engineering Team**

Academic year	1	**Unit Code**	A/651/0708	**Assignment**	1 of 3

Internal Verifier	Dr. Mike Shaw	**Verification Date**	1st September 2025
Issue Date	1st September 2025	**Final Submission Date**	No later than 1st July 2026

Policy on the Use of Artificial Intelligence (AI)

- Students are required to acknowledge the use of AI in the preparation of any assignment.
- AI tools **may be** permissible for use as learning aids, subject to the AI Assessment Scale designation given below.
- AI cannot be used to generate the final, submitted work in its entirety.
- AI cannot be used to substitute for a student's own critical thinking, analysis, and original expression.
- Assignments must reflect the student's original thought and understanding.
- Assignments are checked automatically on submission for AI content, through Turnitin.
- Assignment grades are only confirmed following viva voce examination at the end of each unit.

Artificial Intelligence Assessment Scale (AIAS)

Full details of the Artificial Intelligence Assessment Scale (AIAS) are available at this link.

The AI Assessment Scale (AIAS)

Level	Description	Guidelines
1 **NO AI**	The assessment is completed entirely without AI assistance in a controlled environment, ensuring that students rely solely on their existing knowledge, understanding, and skills.	**You must not use AI at any point during the assessment. You must demonstrate your core skills and knowledge.**
2 **AI PLANNING**	AI may be used for pre-task activities such as brainstorming, outlining and initial research. This level focuses on the effective use of AI for planning, synthesis, and ideation, but assessments should emphasise the ability to develop and refine these ideas independently.	**You may use AI for planning, idea development, and research. Your final submission should show how you have developed and refined these ideas.**
3 **AI COLLABORATION**	AI may be used to help complete the task, including idea generation, drafting, feedback, and refinement. Students should critically evaluate and modify the AI suggested outputs, demonstrating their understanding.	**You may use AI to assist with specific tasks such as drafting text, refining and evaluating your work. You must critically evaluate and modify any AI-generated content you use.**
4 **FULL AI**	AI may be used to complete any elements of the task, with students directing AI to achieve the assessment goals. Assessments at this level may also require engagement with AI to achieve goals and solve problems.	**You may use AI extensively throughout your work either as you wish, or as specifically directed in your assessment. Focus on directing AI to achieve your goals while demonstrating your critical thinking.**
5 **AI EXPLORATION**	AI is used creatively to enhance problem-solving, generate novel insights, or develop innovative solutions to solve problems. Students and educators co-design assessments to explore unique AI applications within the field of study.	**You should use AI creatively to solve the task, potentially co-designing new approaches with your instructor.**

This assignment is based on the AIAS level indicated by the colour above.
Follow the instructions for that level.

If the submitted work falls outside the scope of the AIAS designation above, the assignment will be failed.

References

- Prepare your references and correctly cite them within the body of your assignment using zbib.org.
- Use the Harvard referencing standard of any of the listed UK universities.
- In zbib.org, create a 'Link to this Version' and copy it into your References section.
- **Assignments will be rejected if this process is not followed correctly.**

Submission Format

All text elements of your submission should be word processed; mathematical solutions can be handwritten (neatly) and scanned into your document.

Assignment Format

- **Organisation**: Use clear headings, paragraphs, and sub-sections, to ensure clarity and ease of reading. Refer to Task numbers or sections to make it clear which question you are answering.

Assignment Structure

Your assignment **MUST** include the following sections:

- **Cover Page**: Your Course, Name, Unit Name and Assignment number/name
- **Contents Page**: List tasks or questions with page numbers.
- **References**: Correctly cite and list all sources used, but do not use Wikipedia. Please see the detailed advice on page 1.

Submission Requirements

By submitting your assignment, you confirm the following:

- **Originality**: The work is your own, with all sources properly cited.
- **Plagiarism**: You acknowledge that plagiarism and collusion are forms of academic misconduct and are strictly prohibited.
- **Plagiarism Detection**: Your assignment will be submitted to TurnItIn, a plagiarism detection service, that compares your work against databases, online sources, and other students' work.
- **False Declaration**: Making a false declaration is academic misconduct.

Vocational Scenario or Context	You have recently been hired to work as an engineer for a manufacturer of electrical and mechanical components and systems. Your Line Manager has asked you to evaluate certain mathematical principles, and undertake certain statistical analyses relevant to the products produced at your company.

Task 1 (NO AI)

a) Power (P) dissipated by a resistor with resistance (R) which has a potential difference (V) between its terminals is given by the following formula:

$$P = \frac{V^2}{R}$$

Your Line Manager has asked you to use the dimensions of P and V to determine the dimensions of R.

b) A guitar string, made by your company, has mass (m), length (l), and tension (F). It is proposed by one of your colleagues that a formula for the period of vibration (t) of the string might be:

$$t = 2\pi\sqrt{\frac{m^2 l}{F}}$$

Use dimensional analysis to show your colleague that this formula is incorrect.

c) 15 sample measurements of voltage ramp waveforms are taken from an analogue-to-digital converter (ADC) manufactured by your company. They are measured in mV as follows: 3, 6, 9, 12, 15… 45.

Your colleague has asked you to produce and use a formula to calculate the sum of these 15 voltage samples.

d) A digital Integrated Circuit (IC) chip made by your company counts continuously in the sequence. The first four number in the sequence are 512, 1024, 2048, and 4096.

Produce and use a formula to calculate the 11th count of the chip.

e) A circuit you are testing features a capacitor with capacitance (C) charged by a DC supply voltage (V_S) via resistor with resistance (R). Voltage at the capacitor (V_C) may be determined using the following formula:

$$V_C = V_S\left(1 - e^{-t/RC}\right)$$

Task 1 (NO AI)

t = time.

R = the number of characters in your email address in mega ohms. For example: if your email address is jane.smith@zmail.org, R would be 20MΩ.

V_S = the sum of numbers that make the year of your birth. For example: if you were born in 1994 then we add 1+9+9+4 to arrive at a voltage of 23V.

Clearly state the values of R and V_S. Assuming that V_C is 1V after 4 seconds, determine the approximate value for capacitance.

f) One of your commonly-used laboratory instantaneous test signal voltages (V_S) is described by the following formula:

$$V_S = 8\sin\left(36\pi f t - \frac{\pi}{4}\right)$$

f = 2MHz

Make time (t) the subject of this formula and determine the first point in time when the instantaneous signal voltage has a magnitude of +4V.

Note: A colleague has reminded you that you need to have your calculator in radians mode (RAD) for this calculation, because the angle is given in radians (i.e. π is featured).

Use suitable software (such as Desmos) to draw at least two cycles of this signal and annotate the drawing so that non-technical colleagues may understand it.

g) The curve of a heavy power cable, made by your company, that is hanging at rest may be communicated using the following formula:

$$y = 80\cosh\left(\frac{x}{80}\right)$$

where x and y are horizontal and vertical positions respectively. Calculate:

i) The value of y when x is 120.
ii) The value of x when y is 200.

Task 1 (NO AI)

h) You are testing a decorative clock proposed for manufacture at your company. You attach a mass (m) to a string of length (l) to form a simple pendulum. Assuming the acceleration due to gravity (g) of the earth has an influence on the period (t) of the pendulum swing, use dimensional analysis to find a formula for t which involves m, l, and g.

i) You are testing the voltage across a capacitor in an AC circuit. The instrument you are using reads 150V magnitude at phase angle 60°. Convert this voltage into a complex number.

j) A set of data from a manufacturing robot has been expressed in matrix form as follows:

$$D = \begin{pmatrix} 6 & 2 \\ 4 & 5 \end{pmatrix}$$

Find the inverse of this matrix.

Task 2 (NO AI)

a) Your company manufactures wireless dongles for use in general computing. These dongles have a maximum allowed radiative power of +25dBm. A random sample of ten dongles was taken, and their transmitted power was measured by a colleague using a spectrum analyser. The results are as follows:

Sample	1	2	3	4	5	6	7	8	9	10
Power (+dBm)	22.3	24.1	22.8	22.3	24.9	22.3	21.5	23.9	22.3	21.5

i) Calculate the mean transmit power for these samples.
ii) Calculate the mode of the samples.
iii) Calculate the median of the samples
iv) Determine the standard deviation for the samples.

b) Your company's factory has a machine producing metal bolts that are output into a tray. 96% of the bolts are within the allowable diameter tolerance value. The remainder exceed the tolerance. You take seven bolts at random from the tray. Determine the probabilities that:

i) Two of the seven bolts exceed the tolerable diameter.
ii) More than two of the seven bolts exceed the tolerable diameter.

Task 2 (NO AI)	c) Your company manufactures capacitors; the mean capacitance of 500 capacitors you have selected for quality control testing is 200µF, with a standard deviation of 12µF. If the capacitances are normally distributed, determine the number of capacitors likely to have values between 185µF and 215µF. Use the z-table given in Appendix A. d) A colleague, who is a Fuels engineer, is testing the effects of an experimental fuel additive for petrol engines which your company is developing. She mixes identical quantities of additive to the petrol in 120 full petrol tanks for the same model of car, and records the number of miles per gallon (mpg) achieved by each car after being driven around a test track at a constant speed until the fuel runs out. She knows that such testing undertaken without the additive produces a mean mpg figure of 48. Collecting results with the additive, she notices that the mean mpg figure is 51 with a sample standard deviation of 15 mpg. By interpreting the results of the testing, show whether you agree, or not, with her hypothesis that the fuel additive has influenced the number of miles per gallon for the cars. Draw by hand, or use suitable software, to produce a graphic, suitable for a non-technical company executive, which represents the results of your analysis. Use the z-table given in Appendix A
Sources of information to support you with this Assignment	Bird J. (2021) Higher Engineering Mathematics. 9th Ed. Routledge. Bird J. (2019) Science and Mathematics for Engineering. 6th Ed. Routledge. Glyn J. and Dyke P. (2020) Modern Engineering Mathematics. 6th edition. Pearson. Made Easy Editorial Board (2022) Engineering Mathematics for GATE 2023 and ESE 2023 (Prelims) – Theory and Previous Year Solved Papers. India: Made Easy Publications Pvt Ltd. Rattan K.S., Klingbeil N.W., and Baudendistel C.M. (2021) Introductory Mathematics for Engineering Applications. 2nd Ed. Wiley. Ram M. (2021) Recent Advances in Mathematics for Engineering. CRC Press. Teodorescu P., Stanescu N., and Pandrea N. (2013) Numerical Analysis with Applications in Mechanics and Engineering. Wiley-IEEE Press. Ram M. (2020) Mathematics in Engineering Sciences: Novel Theories, Technologies, and Applications. 1st Edition. CRC Press.

	Sobot, R. (2022) Engineering Mathematics by Example. 1st Ed. Springer. Stroud, K.A. and Booth, D.J. (2020) Engineering Mathematics. 8th Ed. Bloomsbury Publishing Urbano M. (2019) Introductory Electrical Engineering with Math Explained in Accessible Language. Wiley. Vick B. (2020) Applied Engineering Mathematics. CRC Press.

Relevant Learning Outcomes and Assessment Criteria

	Pass	Merit	Distinction
LO1	***Apply a variety of mathematical methods to a range of engineering and manufacturing sector problems***		**LO1 and LO2**
P1	Apply dimensional analysis techniques to solve complex engineering/manufacturing problems.	**M1** Use three mathematical concepts to solve engineering/ manufacturing problems, justifying your chosen methods.	**D1** Present data as meaningful information using appropriate methods that can be understood by a nontechnical audience.
P2	Generate answers from engineering arithmetic and geometric progressions.		
P3	Determine solutions of engineering equations using exponential, logarithmic, trigonometric, and hyperbolic functions.		

Relevant Learning Outcomes and Assessment Criteria

	Pass	Merit	Distinction
LO2	***Investigate applications of statistical and probability techniques to interpret, organise, and present data***		
P4	Investigate engineering data by calculating mean, mode, median, and standard deviation.	**M2** Conduct an engineering hypothesis test and interpret the results.	
P5	Calculate probabilities within Poisson binomially and normally distributed engineering random variables.		

Appendix A										
z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0	0.00399	0.00798	0.01197	0.01595	0.01994	0.02392	0.0279	0.03188	0.03586
0.1	0.03983	0.0438	0.04776	0.05172	0.05567	0.05962	0.06356	0.06749	0.07142	0.07535
0.2	0.07926	0.08317	0.08706	0.09095	0.09483	0.09871	0.10257	0.10642	0.11026	0.11409
0.3	0.11791	0.12172	0.12552	0.1293	0.13307	0.13683	0.14058	0.14431	0.14803	0.15173
0.4	0.15542	0.1591	0.16276	0.1664	0.17003	0.17364	0.17724	0.18082	0.18439	0.18793
0.5	0.19146	0.19497	0.19847	0.20194	0.2054	0.20884	0.21226	0.21566	0.21904	0.2224
0.6	0.22575	0.22907	0.23237	0.23565	0.23891	0.24215	0.24537	0.24857	0.25175	0.2549
0.7	0.25804	0.26115	0.26424	0.2673	0.27035	0.27337	0.27637	0.27935	0.2823	0.28524
0.8	0.28814	0.29103	0.29389	0.29673	0.29955	0.30234	0.30511	0.30785	0.31057	0.31327
0.9	0.31594	0.31859	0.32121	0.32381	0.32639	0.32894	0.33147	0.33398	0.33646	0.33891
1	0.34134	0.34375	0.34614	0.34849	0.35083	0.35314	0.35543	0.35769	0.35993	0.36214
1.1	0.36433	0.3665	0.36864	0.37076	0.37286	0.37493	0.37698	0.379	0.381	0.38298
1.2	0.38493	0.38686	0.38877	0.39065	0.39251	0.39435	0.39617	0.39796	0.39973	0.40147
1.3	0.4032	0.4049	0.40658	0.40824	0.40988	0.41149	0.41308	0.41466	0.41621	0.41774
1.4	0.41924	0.42073	0.4222	0.42364	0.42507	0.42647	0.42785	0.42922	0.43056	0.43189
1.5	0.43319	0.43448	0.43574	0.43699	0.43822	0.43943	0.44062	0.44179	0.44295	0.44408
1.6	0.4452	0.4463	0.44738	0.44845	0.4495	0.45053	0.45154	0.45254	0.45352	0.45449
1.7	0.45543	0.45637	0.45728	0.45818	0.45907	0.45994	0.4608	0.46164	0.46246	0.46327
1.8	0.46407	0.46485	0.46562	0.46638	0.46712	0.46784	0.46856	0.46926	0.46995	0.47062
1.9	0.47128	0.47193	0.47257	0.4732	0.47381	0.47441	0.475	0.47558	0.47615	0.4767
2	0.47725	0.47778	0.47831	0.47882	0.47932	0.47982	0.4803	0.48077	0.48124	0.48169
2.1	0.48214	0.48257	0.483	0.48341	0.48382	0.48422	0.48461	0.485	0.48537	0.48574
2.2	0.4861	0.48645	0.48679	0.48713	0.48745	0.48778	0.48809	0.4884	0.4887	0.48899
2.3	0.48928	0.48956	0.48983	0.4901	0.49036	0.49061	0.49086	0.49111	0.49134	0.49158
2.4	0.4918	0.49202	0.49224	0.49245	0.49266	0.49286	0.49305	0.49324	0.49343	0.49361
2.5	0.49379	0.49396	0.49413	0.4943	0.49446	0.49461	0.49477	0.49492	0.49506	0.4952
2.6	0.49534	0.49547	0.4956	0.49573	0.49585	0.49598	0.49609	0.49621	0.49632	0.49643
2.7	0.49653	0.49664	0.49674	0.49683	0.49693	0.49702	0.49711	0.4972	0.49728	0.49736
2.8	0.49744	0.49752	0.4976	0.49767	0.49774	0.49781	0.49788	0.49795	0.49801	0.49807
2.9	0.49813	0.49819	0.49825	0.49831	0.49836	0.49841	0.49846	0.49851	0.49856	0.49861
3	0.49865	0.49869	0.49874	0.49878	0.49882	0.49886	0.49889	0.49893	0.49896	0.499
3.1	0.49903	0.49906	0.4991	0.49913	0.49916	0.49918	0.49921	0.49924	0.49926	0.49929
3.2	0.49931	0.49934	0.49936	0.49938	0.4994	0.49942	0.49944	0.49946	0.49948	0.4995
3.3	0.49952	0.49953	0.49955	0.49957	0.49958	0.4996	0.49961	0.49962	0.49964	0.49965
3.4	0.49966	0.49968	0.49969	0.4997	0.49971	0.49972	0.49973	0.49974	0.49975	0.49976
3.5	0.49977	0.49978	0.49978	0.49979	0.4998	0.49981	0.49981	0.49982	0.49983	0.49983
3.6	0.49984	0.49985	0.49985	0.49986	0.49986	0.49987	0.49987	0.49988	0.49988	0.49989
3.7	0.49989	0.4999	0.4999	0.4999	0.49991	0.49991	0.49992	0.49992	0.49992	0.49992
3.8	0.49993	0.49993	0.49993	0.49994	0.49994	0.49994	0.49994	0.49995	0.49995	0.49995
3.9	0.49995	0.49995	0.49996	0.49996	0.49996	0.49996	0.49996	0.49996	0.49997	0.49997
4.0	0.49997	0.49997	0.49997	0.49997	0.49997	0.49997	0.49998	0.49998	0.49998	0.49998