2019-DSE MATH EP M2

> HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2019

#### MATHEMATICS Extended Part Module 2 (Algebra and Calculus) Question-Answer Book

8:30 am - 11:00 am (2½ hours) This paper must be answered in English

#### INSTRUCTIONS

- (1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7, 9, 11 and 13.
- (2) This paper consists of TWO sections, A and B.
- (3) Attempt ALL questions in this paper. Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.
- (4) Graph paper and supplementary answer sheets will be supplied on request. Write your Candidate Number, mark the question number box and stick a barcode label on each sheet, and fasten them with string INSIDE this book.
- (5) Unless otherwise specified, all working must be clearly shown.
- (6) Unless otherwise specified, numerical answers must be exact.
- (7) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

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#### FORMULAS FOR REFERENCE

|        | $\sin (A \pm B) = \sin A \cos B \pm \cos A \sin B$ $\cos (A \pm B) = \cos A \cos B \mp \sin A \sin B$ $\tan (A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$ | $\sin A + \sin B = 2\sin \frac{A+B}{2}\cos \frac{A-B}{2}$ $\sin A - \sin B = 2\cos \frac{A+B}{2}\sin \frac{A-B}{2}$ $\cos A + \cos B = 2\cos \frac{A+B}{2}\cos \frac{A-B}{2}$ |  |
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| SEC    | TION A (50 marks)  |   |  |
| 1.     | Let $f(x) = \frac{10x}{7+3x^2}$ . Prove that $f(1+h) - f(1)$   | $=\frac{4h-3h^2}{10+6h+3h^2}$ . Hence, find f'(1)   | from first                                 |
|        | principles.  |   | (4 marks)                                  |
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| 2. | Let $P(x) = \begin{vmatrix} x + \lambda & 1 & 2 \\ 0 & (x + \lambda)^2 & 3 \\ 4 & 5 & (x + \lambda)^3 \end{vmatrix}$ , where $\lambda \in \mathbb{R}$ . It is given that the coefficient of expansion of $P(x)$ is 160. Find   | $x^3$ in the   |
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|    | (a) $\lambda$ , .  |  |
|    | (b) $P'(0)$ .  |  |
|    |  | (5 marks)  |
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| 3, |                                     | earcher performs an experiment to study the rate of change of the volume of liquid $X$ in a vessel, xperiment lasts for 24 hours. At the start of the experiment, the vessel contains 580 cm <sup>3</sup> of |
|----|-------------------------------------|--|
|    |                                     | X. The researcher finds that during the experiment, $\frac{dV}{dt} = -2t$ , where $V \text{ cm}^3$ is the volume   |
|    |                                     | dt<br>and X in the vessel and t is the number of hours elapsed since the start of the experiment.  |
|    | (a)                                 | The researcher claims that the vessel contains some liquid $X$ at the end of the experiment. Is the claim correct? Explain your answer.  |
|    | (b)                                 | It is given that $V = h^2 + 24h$ , where <i>h</i> cm is the depth of liquid X in the vessel. Find the value of $\frac{dh}{dt}$ when $t = 18$ .   |
|    |                                     | dt (6 marks)   |
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|  | ne $g(x) = \frac{\ln x}{\sqrt{x}}$ for all $x \in (0, 99)$ . Denote the graph of $y = g(x)$ by G.  |
|--|--|
| (a)  | Prove that $G$ has only one maximum point.   |
| (b)  | Let $R$ be the region bounded by $G$ , the x-axis and the vertical line passing through the maximum point of $G$ . Find the volume of the solid of revolution generated by revolving about the x-axis. |
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Using mathematical induction, prove that  $\sum_{k=n}^{2n} \frac{1}{k(k+1)} = \frac{n+1}{n(2n+1)}$ for all positive integers n. 5. (a) Using (a), evaluate  $\sum_{k=50}^{200} \frac{1}{k(k+1)}$ . (b) (7 marks) Answers written in the margins will not be marked. Answers written in the margins will not be marked.

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|  | consider the system of linear equations in real variables x, y, z<br>$\begin{cases} x - 2y - 2z = \beta \end{cases}$   |
|--|--|
|  | (E): $\begin{cases} x - 2y - 2z = \beta \\ 5x + \alpha y + \alpha z = 5\beta \\ 7x + (\alpha - 3)y + (2\alpha + 1)z = 8\beta \end{cases}$ , where $\alpha, \beta \in \mathbb{R}$ . |
| (a)  | Assume that (E) has a unique solution.   |
|  | (i) Find the range of values of $\alpha$ .   |
|  | (ii) Express y in terms of $\alpha$ and $\beta$ .  |
| (b)  | Assume that $\alpha = -4$ . If (E) is inconsistent, find the range of values of $\beta$ . (7 marks)  |
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Using integration by parts, find  $\int e^x \sin \pi x \, dx$ . 7. (a) Using integration by substitution, evaluate  $\int_0^3 e^{3-x} \sin \pi x \, dx$ . (b) (7 marks) Answers written in the margins will not be marked. Answers written in the margins will not be marked.

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| 8. |  | h(x) be a continuous function defined on $\mathbb{R}^+$ , where $\mathbb{R}^+$ is the set of positive regiven that $h'(x) = \frac{2x^2 - 7x + 8}{x}$ for all $x > 0$ . | real numbers.   |
|----|--|--|---|
|    | (a)  | Is $h(x)$ an increasing function? Explain your answer.   |   |
|    | (b)  | Denote the curve $y = h(x)$ by H. It is given that H passes through the point (1,  | 3) . Find   |
|    |  | (i) the equation of $H$ ,  |   |
|    |  | (ii) the point(s) of inflexion of $H$ .  | (8 marks)   |
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|  | 9.   | Cons:<br>by L   |   | e curve $\Gamma$ : $y = \frac{1}{3}\sqrt{12 - x^2}$ , where $0 < x < 2\sqrt{3}$ . Denote the tangent to $\Gamma$ | at $x = 3$  |
|  |      | (a)   |   | the equation of $L$ .  | (3 marks)   |
|  |      | (b)   | Let (   | C be the curve $y = \sqrt{4 - x^2}$ , where $0 < x < 2$ . It is given that L is a tangent to                     | o C. Find   |
|  |      |   | (i)   | the point(s) of contact of $L$ and $C$ ;   |   |
|  |      |   | (ii)  | the point(s) of intersection of $C$ and $\Gamma$ ;   | ·   |
|  |      |   | (iii)   | the area of the region bounded by $L$ , $C$ and $\Gamma$ .   | (9 marks)   |
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 . Prove that  $\frac{1}{2 + \cos 2x} = \frac{\sec^2 x}{2 + \sec^2 x}$ .
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(b) Evaluate  $\int_0^{\frac{\pi}{4}} \frac{1}{2 + \cos 2x} dx$ .
(3 marks)

(c) Let  $f(x)$  be a continuous function defined on R such that  $f(-x) = -f(x)$  for all  $x \in \mathbb{R}$ .
Prove that  $\int_{-\pi}^{\pi} f(x) \ln(1 + e^x) dx = \int_{0}^{\pi} xf(x) dx$  for any  $a \in \mathbb{R}$ .
(4 marks)

(d) Evaluate  $\int_{-\pi}^{\frac{\pi}{4}} \frac{\sin 2x}{(2 + \cos 2x)^2} \ln(1 + e^x) dx$ .
(5 marks)

(e) Let  $f(x)$  be a continuous function defined on R such that  $f(-x) = -f(x)$  for all  $x \in \mathbb{R}$ .
(4 marks)

(d) Evaluate  $\int_{-\frac{\pi}{4}}^{\frac{\pi}{4}} \frac{\sin 2x}{(2 + \cos 2x)^2} \ln(1 + e^x) dx$ .
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| (a)                                      | Find a pair of real numbers $a$ and $b$ such that $M^2 = aM + bI$ .  | (3 marks)  |
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| (b)                                      | Prove that $6M^n = (1 - (-5)^n)M + (5 + (-5)^n)I$ for all positive integers $n$ .  | (4 marks)  |
| (0)                                      |  |  |
| (c)                                      | Does there exist a pair of 2×2 real matrices A and B such that $(M^n)^{-1} = A + \frac{1}{(-5)^n}$   |  |
|  | positive integers $n$ ? Explain your answer.   | (5 marks)  |
| - Andreas (areas                         | <i>ՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠՠ</i>   | ે<br>મોલ્લી-બોલીબી દેવનાં અલ્લાનાં તેમ લોલાય છે લ  |
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|  | -6)+   | ŊŊſĊŀŀŀĬŊſġĿĊſĸĄĊŎĿŎŖĬŊSĸĊŀĊŴŊĬŎĸŎĿŎĿĹŎĿŎĿĹ   | ФФУФФИНТНАЛАДИНИ ПОПОЛЬ-Б-Салар Ge  | etertişteri (sanaa qarga tartara tartara sa                                 | \$4994935028124104903597916653572869555694   | adaanaa ah gabaraa ah ah daa  | 1.0.10.10.10.10.10.10.10.10.10.10.10.10.   | aa) maana aha maa ahaa ahaa ahaa ahaa ahaa   |
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| Find<br>Dence<br>lying<br>on <i>I</i><br>(i)<br>(ii)   | the volume of the pyramid <i>OABC</i> . (2 mark<br>te the plane which contains A, B and C by $\Pi$ . It is given that P, Q and R are poin<br>on $\Pi$ such that $\overrightarrow{OP} = p\mathbf{i}$ , $\overrightarrow{OQ} = q\mathbf{j}$ and $\overrightarrow{OR} = r\mathbf{k}$ . Let D be the projection of<br>$\Pi$ .<br>Prove that $pqr \neq 0$ .<br>Find $\overrightarrow{OD}$ .<br>Let E be a point such that $\overrightarrow{OE} = \frac{1}{p}\mathbf{i} + \frac{1}{q}\mathbf{j} + \frac{1}{r}\mathbf{k}$ . Describe the geometric relationsh<br>between D, E and O. Explain your answer. |
| Dence<br>lying<br>on <i>I</i><br>(i)<br>(ii)   | te the plane which contains $A$ , $B$ and $C$ by $\Pi$ . It is given that $P$ , $Q$ and $R$ are point<br>on $\Pi$ such that $\overrightarrow{OP} = p\mathbf{i}$ , $\overrightarrow{OQ} = q\mathbf{j}$ and $\overrightarrow{OR} = r\mathbf{k}$ . Let $D$ be the projection of<br>$\Pi$ .<br>Prove that $pqr \neq 0$ .<br>Find $\overrightarrow{OD}$ .<br>Let $E$ be a point such that $\overrightarrow{OE} = \frac{1}{p}\mathbf{i} + \frac{1}{q}\mathbf{j} + \frac{1}{r}\mathbf{k}$ . Describe the geometric relationship<br>between $D$ , $E$ and $O$ . Explain your answer.                       |
| lying<br>on <i>l</i><br>(i)<br>(ii)  | on $\Pi$ such that $\overrightarrow{OP} = p\mathbf{i}$ , $\overrightarrow{OQ} = q\mathbf{j}$ and $\overrightarrow{OR} = r\mathbf{k}$ . Let $D$ be the projection of $I$ .<br>Prove that $pqr \neq 0$ .<br>Find $\overrightarrow{OD}$ .<br>Let $E$ be a point such that $\overrightarrow{OE} = \frac{1}{p}\mathbf{i} + \frac{1}{q}\mathbf{j} + \frac{1}{r}\mathbf{k}$ . Describe the geometric relationsh between $D$ , $E$ and $O$ . Explain your answer.  |
| (ii)   | Find $\overrightarrow{OD}$ .<br>Let <i>E</i> be a point such that $\overrightarrow{OE} = \frac{1}{p}\mathbf{i} + \frac{1}{q}\mathbf{j} + \frac{1}{r}\mathbf{k}$ . Describe the geometric relationsh between <i>D</i> , <i>E</i> and <i>O</i> . Explain your answer.  |
|  | Let <i>E</i> be a point such that $\overrightarrow{OE} = \frac{1}{p}\mathbf{i} + \frac{1}{q}\mathbf{j} + \frac{1}{r}\mathbf{k}$ . Describe the geometric relationsh between <i>D</i> , <i>E</i> and <i>O</i> . Explain your answer.  |
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