**Stage 2 Mathematical Methods**

**Differential Calculus Test**

**Topic 1: Subtopics 1.1, 1.2, 1.5**

**Total Marks – 60**

**This Skills and Applications Task is to be completed without a calculator or notes.**

1. (12 marks)

Differentiate the following. There is no need to simplify your answers.

1. $f\left(x\right)=\frac{1}{3}x^{12}+5x$

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(1 mark)

1. $y=2.\sqrt[3]{x}$

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(1 mark)

1. $s\left(t\right)=\frac{t^{5}}{5}-\frac{5}{t^{5}}+5$

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(2 marks)

1. $y=\frac{1}{\sqrt{4-x}}$

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(2 marks)

1. $A\left(x\right)=\frac{5\left(2x^{2}-5x\right)^{3}}{3}$

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(2 marks)

1. $f\left(x\right)=x\left(2+\sqrt{x}\right)^{4}$

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(2 marks)

1. $f\left(x\right)=\frac{\left(6x-1\right)^{3}}{\sqrt{3-x}}$

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(2 marks)

1. (4 marks)

Find, from first principles, $f^{'}\left(x\right)$ if $f\left(x\right)=x^{2}-5x$

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(4 marks)

1. (4 marks)

Find the equation, in the form $Ax+By=C$, of the **NORMAL** to $y=\frac{1}{2-x}$ at the point $\left(-2, \frac{1}{4}\right)$.

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(4 marks)

1. (13 marks)

Consider the graph of the function $f\left(x\right)=\frac{4x}{x^{2}+4}-1$.

1. Find the axis intercepts of the graph.

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(2 marks)

1. Clearly show that $f'\left(x\right)=-\frac{4\left(x^{2}-4\right)}{\left(x^{2}+4\right)^{2}}$

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(3 marks)

1. Algebraically find the *coordinates* and the *nature* of the stationary point(s) of the graph of $y=f\left(x\right)$.

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(6 marks)

1. Sketch the graph of $y=f(x)$ for $-5\leq x\leq 5$ showing the features found in parts (a) and (c) above.

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(2 marks)

1. (19 marks)

A model train travels along a straight tack with position $s\left(t\right)$ (in metres relative to a signal tower) given by $s\left(t\right)=5+12t-9t^{2}+2t^{3}$ for $t\geq 0$ where $t$ is the time in minutes.

1. Determine the train’s initial position.

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(1 mark)

1. Write down expressions for the train’s velocity and acceleration.

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(2 marks)

1. Algebraically find the train’s positions when it stops and changes direction.

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(4 marks)

1. Does the train return to its original position? Give a reason for your answer.

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(2 marks)

1. Find when the acceleration is zero and then draw sign diagrams for both the velocity and the acceleration of the train.

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(3 marks)

1. When is the train speeding up?

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(2 marks)

1. What is the minimum velocity of the train?

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(1 mark)

1. Determine how far the train travels in the first 3 minutes.

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(4 marks)

1. (8 marks)

The population of rabbits in a national park in the period following the release of a rabbit virus can be modelled by $P\left(t\right)=\frac{2}{3}t^{3}-23t^{2}+240t+5.3$ for $0\leq t\leq 20$, where $t$ is the time in weeks since the virus’ release and $P$ is the population of rabbits in thousands.

1. Write down an expression for $P'\left(t\right)$.

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(2 marks)

1. What is the meaning of $P'\left(t\right)$ in the context of the situation?

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(1 mark)

1. Solve $P'\left(t\right)=0$ for $0\leq t\leq 20$.

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(2 marks)

1. Draw a sign diagram of $P'\left(t\right)$ and then use it to describe what is happening to the rabbit population for $0\leq t\leq 20$.

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(2 marks)

1. When is the rabbit population decreasing at its fastest rate?

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(1 mark)