**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. (10 marks)

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

1. $y=6x^{3}+\frac{2}{\sqrt{x}}$

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(2 marks)

1. $f\left(x\right)=\frac{3x^{2}-6x-4}{x}$

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(2 marks)

1. $p\left(t\right)=\left(5t^{2}+4t\right)^{3}$

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(2 marks)

1. $A\left(x\right)=-5x^{4}\left(3x+2\right)^{6}$

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(2 marks)

1. $y=\frac{12.\sqrt[3]{x}}{\left(5-3x\right)^{2}}$

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(2 marks)

1. (5 marks)

Find, from first principles, $f^{'}\left(3\right)$ if $f\left(x\right)=1-\frac{1}{x}$

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(5 marks)

1. (4 marks)

Find the equation, in the form $Ax+By=C$, of the **TANGENT** to $y=\frac{x}{x+1}$ at the point where $x=3$.

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(4 marks)

1. (14 marks)

The function $f\left(x\right)=-x^{3}+ax^{2}+24x-10$ has a stationary point at $x=-2$.

1. Explain why $f^{'}\left(-2\right)=0$.

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(1 mark)

1. Hence show that $a=3$.

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(2 marks)

1. Find and classify the stationary points of $f\left(x\right)$. (Make sure you include a sign diagram.)

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(4 marks)

1. Find the point of inflection of $f\left(x\right)$ and use a sign diagram to determine what shape change is occurring at this point.

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(3 marks)

1. Is the point you found in part (d) classed as a horizontal or a non-horizontal inflection point?

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(2 marks)

1. Sketch the graph of $y=f\left(x\right)$ labelling all the information from parts (c), (d) and (e).

$$x$$

$$y$$

$$-8$$

$$-7$$

$$-6$$

$$-5$$

$$-4$$

$$-3$$

$$-2$$

$$-1$$

$$1$$

$$2$$

$$3$$

$$4$$

$$5$$

$$6$$

$$7$$

$$8$$

$$-80$$

$$-60$$

$$-40$$

$$-20$$

$$20$$

$$40$$

$$60$$

80

(2 marks)

1. (17 marks)

A particle moves in a straight line such that its position $t$ seconds after it has passed through the origin, $O$, is given by $s\left(t\right)=-t^{3}+9t^{2}-24t+20$ metres,$ t\geq 0$.

1. Find expressions for the velocity and acceleration of the particle after $t$ seconds.

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(2 marks)

1. Find when the particle is at rest and its position at these times.

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(4 marks)

1. Hence or otherwise, determine the time when the particle **PASSES THROUGH** the origin.

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(1 mark)

1. Draw sign diagrams for $v\left(t\right)$ and $a\left(t\right)$ and determine the time(s) when the particle’s speed is **INCREASING**.

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(4 marks)

1. Draw a diagram to illustrate the motion of the particle.

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(2 marks)

1. Calculate the total distance travelled by the particle in the first 10 seconds of its motion.

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(4 marks)

1. (10 marks)

The population of an isolated mining town changed dramatically during the months following the announcement of the discovery of gold. The population, $P\left(n\right)$, $n$ months after the announcement was given by the rule $P\left(n\right)=25-n^{3}\left(n-10\right)$, $0\leq n\leq 10$.

1. Determine the initial population.

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(1 mark)

1. Determine how much the population had grown 3 months after the announcement.

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(2 marks)

1. Expand the expression for $P\left(n\right)$ and show that $P^{'}\left(n\right)=-4n^{3}+30n^{2}$.

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(1 mark)

1. Find the rate at which the population is changing after 2 months and also after 10 months.

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(2 marks)

1. When was the population at its maximum?

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(2 marks)

1. When was the population increasing at its maximum rate?

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(2 marks)