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APRIL EXAMINATION

NATIONAL CERTIFICATE

MATHEMATICS N5

(16030175)

4 April 2016 (X-Paper)
09:00–12:00

Scientific calculators may be used.

This question paper consists of 6 pages and 1 formula sheet of 5 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
MATHEMATICS N5
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Show ALL intermediate steps and simplify where possible.
5. ALL final answers must be rounded off to THREE decimal places.
6. Questions may be answered in any order, but subsections of questions must be kept together.
7. Use ONLY blue or black ink.
8. Write neatly and legibly.

QUESTION 1

1.1 Determine the following limits:

1.1.1 $\lim\limits_{x \to 0} \dfrac{e^x}{xe^x - 2x}$ (2)

1.1.2 $\lim\limits_{x \to \frac{\pi}{2}} (\sec x - \tan x)$ (3)

1.2 Determine whether $f(x) = \dfrac{x^3 - 27}{x - 3}$ is continuous at $x = -3$. (2)

[7]

QUESTION 2

2.1 Determine the derivative of $f(x) = \cos x$ from first principles.

HINT: $\lim\limits_{h \to 0} \dfrac{\cosh - 1}{h} = 0 \quad ; \lim\limits_{h \to 0} \dfrac{\sinh}{h} = 1$ (4)

2.2 Determine $\dfrac{dy}{dx}$ in each of the following cases (simplification is not required):

2.2.1 $y = \cos^4(x^2 - 4) + \cos(x^2 - 4)^4$ (4)

2.2.2 $y = \dfrac{3\tan^2\sqrt{1-x}}{2\ln cosec 4x}$ (5)

2.2.3 $y = arc\sec(2.4^{3x})$ (2)

2.3 Determine $\dfrac{dy}{dx}$ with the aid of logarithmic differentiation if:

$\arcsin(\sin y) = (x^{e^x})$ (4)

2.4 Given: $3x^4 - xy = 2^{3x}$

2.4.1 Determine the slope $\dfrac{dy}{dx}$ of the tangent at the point: (1;-5). (3)

2.4.2 Hence, determine the equation of the tangent at this point. (2)

[24]

QUESTION 3

3.1 Given: $f(x) = x(x^2 - 5) - 4$

3.1.1 Determine the co-ordinates of the turning points of $f(x)$. (3)

3.1.2 Verify, using a table, that the equation $0 = x(x^2 - 5) - 4$ has a root between the points $x = 2$ and $x = 3$.

Use values on the table: $0 \leq x \leq 4$ (4)

3.1.3 Hence, make a neat sketch of the graph of the function $f(x)$. (2)

3.1.4 If the positive root of $f(x)$ is estimated as 2,7, use Taylor's/Newton's method to determine a better approximation of this root. (4)

3.2 Two sides of a rectangle are lengthened at a rate of 3 cm/s while the other two sides are being shortened in such a way that the figure remains a rectangle with a constant area of 50 cm^2.

3.2.1 Calculate the rate of change of the perimeter of the rectangle when the length of an increasing side is 7 cm. (5)

3.2.2 Prove that when the rate of change of the perimeter is zero, the figure must be a square. (2)

3.3 A particle moves in a straight line according to the distance formula $s(t) = \sqrt{t}(3 - 3t - t^2)$.

3.3.1 Calculate the velocity of the particle after 3,5 seconds. (4)

3.3.2 Calculate the acceleration after 2 seconds. (3)

[27]

QUESTION 4

4.1 Determine: $\int (e^x + e^{-x})^4.(e^x - e^{-x})dx$ (2)

4.2 Determine $\int ydx$ in each of the following cases:

4.2.1 $y = \dfrac{\sin x}{\sqrt{1+\cos x}}$ (3)

4.2.2 $y = x.\sec^2 x$ (3)

4.2.3 $y = \cos 6x.\cos 2x$ (2)

4.2.4 $y = \dfrac{2}{3+4x^2}$ (3)

4.3 Determine $\int ydx$ by resolving the integrand into partial fractions:

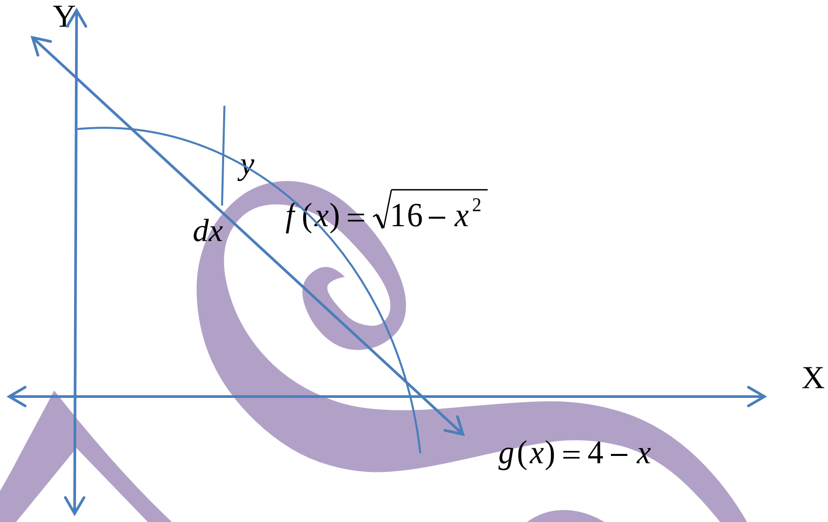
$y = \dfrac{x^3 - 2}{x^4 - 1}$ (5)

4.4 Determine: $\int \dfrac{x^2}{x-5}dx$ (4)

[22]

QUESTION 5

5.1 Given: The curves $f(x)=\sqrt{16-x^2}$ and $g(x)=4-x$



5.1.1 Calculate the magnitude of the enclosed area. (3)

5.1.2 Calculate the volume generated when this area rotates about the x-axis. (4)

5.2 Prove that $\int_0^{\infty} -5e^{-st}\,dt = -\frac{5}{s}$ (4)

[11]

QUESTION 6

6.1 Solve the differential equation:

$$\frac{dy}{dx}=\frac{\tan^2 y}{\operatorname{cosec}^2 x}$$ (4)

6.2 Determine the particular solution of the differential equation $\frac{d^2y}{dx^2}=-\frac{1}{2}x^2+\frac{3}{2}x+\pi$ for which $y=2$ and $y'=-3$ when $x=1$. (5)

[9]

TOTAL: 100

FORMULA SHEET

Any other applicable formulas may also be used.

TRIGONOMETRY

$\sin^2 x + \cos^2 x = 1$

$1 + \tan^2 x = \sec^2 x$

$1 + \cot^2 x = \operatorname{cosec}^2 x$

$\sin 2A = 2 \sin A.\cos A$

$\cos 2A = \cos^2 A - \sin^2 A$

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

$$\sin^2 A = \frac{1}{2} - \frac{1}{2}\cos 2A$$

$$\cos^2 A = \frac{1}{2} + \frac{1}{2}\cos 2A$$

$\sin (A \pm B) = \sin A.\cos B \pm \sin B.\cos A$

$\cos (A \pm B) = \cos A.\cos B \mp \sin A.\sin B$

$$\tan (A \pm B) = \frac{\tan A \pm \tan B}{1 - \tan A.\tan B}$$

$\sin A.\cos B = \frac{1}{2} [\sin(A + B) + \sin (A - B)]$

$\cos A.\sin B = \frac{1}{2} [\sin(A + B) - \sin(A - B)]$

$\cos A.\cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$

$\sin A.\sin B = \frac{1}{2} [\cos(A - B) - \cos(A + B)]$

$$\tan x = \frac{\sin x}{\cos x} ; \sin x = \frac{1}{\operatorname{cosec} x} ; \cos x = \frac{1}{\sec x}$$

BINOMIAL THEOREM

$$(x + h)^n = x^n + n.x^{n-1}h + \frac{n(n-1)}{2!}x^{n-2}h^2 + \ldots$$

DIFFERENTIATION

$$e = -\frac{f(a)}{f'(a)}$$

$$r = a + e$$

PRODUCT RULE

$$y = u(x).v(x)$$

$$\frac{dy}{dx} = u.\frac{dv}{dx} + v.\frac{du}{dx}$$

$$= u.v' + v.u'$$

QUOTIENT RULE

$$y = \frac{u(x)}{v(x)}$$

$$\frac{dy}{dx} = \frac{v.\frac{du}{dx} - u.\frac{dv}{dx}}{v^2}$$

$$= \frac{v.u' - u.v'}{v^2}$$

CHAIN RULE

$$y = f(u(x))$$

$$\frac{dy}{dx} = \frac{dy}{du}.\frac{du}{dx}$$

$f(x)$	$\frac{d}{dx} f(x)$	$\int f(x)dx$
ax^n	nax^{n-1}	$\frac{ax^{n+1}}{n+1} + c$
a	0	$ax + c$
e^x	e^x	$e^x + c$
a^x	$a^x.\ln a$	$\frac{a^x}{\ln a} + c$
$\log_e x$	$\frac{1}{x}$	—
$\log_a x$	$\frac{1}{x \ln a}$	—
$\sin x$	$\cos x$	$-\cos x + c$
$\cos x$	$-\sin x$	$\sin x + c$
$\tan x$	$\sec^2 x$	$\ln(\sec x) + c$
$\cot x$	$-\mathrm{cosec}^2 x$	$\ln(\sin x) + c$
$\sec x$	$\sec x.\tan.$	$\ln[\sec x + \tan x] + c$
$\mathrm{cosec}\, x$	$-\mathrm{cosec}\, x.\cot x$	$\ln[\mathrm{cosec}\, x - \cot x] + c$
$\sin^{-1} x$	$\frac{1}{\sqrt{1-x^2}}$	—
$\cos^{-1} x$	$\frac{-1}{\sqrt{1-x^2}}$	—
$\tan^{-1} x$	$\frac{1}{1+x^2}$	—
$\cot^{-1} x$	$\frac{-1}{1+x^2}$	—
$\sec^{-1} x$	$\frac{1}{x\sqrt{x^2-1}}$	—
$\mathrm{cosec}^{-1} x$	$\frac{-1}{x\sqrt{x^2-1}}$	—

$f(x)$	$\frac{d}{dx} f(x)$	$\int f(x)dx$
$\frac{1}{\sqrt{a^2 - x^2}}$	—	$\sin^{-1}\left(\frac{x}{a}\right) + c$
$\frac{1}{a^2 + x^2}$	—	$\frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right) + c$
$\frac{1}{x\sqrt{x^2 - a^2}}$	—	$\frac{1}{a}\sec^{-1}\left(\frac{x}{a}\right) + c$
$\sqrt{a^2 - x^2}$	—	$\frac{a^2}{2}\sin^{-1}\left(\frac{x}{a}\right) + \frac{x}{2}\sqrt{a^2 - x^2} + c$
$\frac{1}{x^2 - a^2}$	—	$\frac{1}{2a} ln\left(\frac{x - a}{x + a}\right) + c$
$\frac{1}{a^2 - x^2}$	—	$\frac{1}{2a} ln\left(\frac{a + x}{a - x}\right) + c$

INTEGRATION

$$\int f(x).g'(x) = f(x).g(x) - \int f'(x).g(x)dx$$

$$\int \frac{f'(x)}{f(x)}dx = \ln f(x) + c$$

$$\int [f(x)]^n . f'(x)dx = \frac{f(x)^{n+1}}{n+1} + c$$

$$\frac{f(x)}{(ax+b)(cx+d)} = \frac{A}{ax+b} + \frac{B}{cx+d}$$

$$\frac{f(x)}{(x+a)^n} = \frac{A}{(x+a)} + \frac{B}{(x+a)^2} + \frac{C}{(x+a)^3} + \ldots + \frac{Z}{(x+a)^n}$$

APPLICATIONS OF INTEGRATION

AREAS

$$A_x = \int_a^b ydx; \quad A_x = \int_a^b (y_2 - y_1)dx$$

$$A_y = \int_a^b xdy; \quad A_y = \int_a^b (x_2 - x_1)dy$$

VOLUMES

$$V_x = \pi\int_a^b y^2 dx \; ; V_x = \pi\int_a^b \left(y_2{}^2 - y_1{}^2\right) dx$$

$$V_y = \pi\int_a^b x^2 dy \; ; V_y = \pi\int_a^b \left(x_2{}^2 - x_1{}^2\right) dy$$

SECOND MOMENT OF AREA

$$I_x = \int_a^b r^2 dA \; ; I_y = \int_a^b r^2 dA$$

MOMENTS OF INERTIA

Mass = density × volume

$M = pV$

DEFINITION: $I = m\, r^2$

GENERAL: $I = \int_a^b r^2 dm = \rho\int_a^b r^2 dV$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

MATHEMATICS N5

4 APRIL 2016

This marking guideline consists of 10 pages.

INSTRUCTIONS AND INFORMATION

1. Half marks are not allocated, unless indicated otherwise.

2. Where formula is required, using the wrong formula is a principle error and NO marks are allocated.

3. Students should show ALL formulae and intermediate steps and simplify where possible.

4. ALL final answers must be rounded off to THREE decimal places (unless indicated otherwise).

5. Questions may be answered in any order, but subsections of questions must be kept together. If subsections are separated, the student can be penalised by ONE mark.

6. Where a student copied wrong from the question paper, and the standard of the question is still the same, the student will be penalised by ONE mark.
   If the copying error simplifies the question and makes it easier, the student forfeits the marks.

7. Questions must be answered in blue or black ink. Answers in PENCIL will not be marked as it is regarded as rough work.

QUESTION 1

1.1 1.1.1

$$\lim_{x\to 0}\frac{e^x}{xe^x-2x}$$

$$=\frac{1}{0} \checkmark$$
$$=\infty \checkmark$$

(2)

1.1.2

$$\lim_{x\to\frac{\pi}{2}}(\sec x-\tan x)$$

$$=\lim_{x\to\frac{\pi}{2}}\frac{1-\sin x}{\cos x}\left(\frac{0}{0}\right) \checkmark$$

$$=\lim_{x\to\frac{\pi}{2}}\frac{-\cos x}{-\sin x} \checkmark$$

$$=\frac{0}{-1}$$
$$=0 \checkmark$$

(3)

1.2

$$f(-3)=\frac{(-3)^3-27}{x-3}=\frac{-54}{-6}=9 \checkmark$$
$$f(x) is \quad continuous at\ x=\text{-}3 \checkmark$$

(2)
[7]

QUESTION 2

2.1

WENK: $\lim_{h\to 0}\frac{\cosh-1}{h}=0 \quad ;\lim_{h\to 0}\frac{\sinh}{h}=1$

$$\lim_{h\to 0}\frac{\cos(x+h)-\cos x}{h} \checkmark$$
$$=\lim_{h\to 0}\frac{\cos x.\cosh-\sin x.\sinh-\cos x}{h} \checkmark$$
$$=\lim_{h\to 0}\cos x.\frac{\cosh-1}{h}-\sin x.\frac{\sinh}{h} \checkmark$$
$$=\cos x(0)-\sin x(1)$$
$$=-\sin x \checkmark$$

(4)

2.2 2.2.1

$$y=\cos^4(x^2-4)+\cos(x^2-4)^4$$
$$=\underset{\checkmark}{4\cos^3(x^2-4)}.\underset{\checkmark}{-\sin(x^2-4).2x} \quad - \quad \underset{\checkmark}{\sin(x^2-4)^4}.\underset{\checkmark}{4(x^2-4)^3.2x}$$

(4)

2.2.2
$$= \frac{6\tan\sqrt{1-x}.\sec^2\sqrt{1-x}.\frac{-1}{2\sqrt{1-x}}.2\ln\operatorname{cosec}4x - 3\tan^2\sqrt{1-x}.\frac{-8\operatorname{cosec}4x.\cot 4x}{\operatorname{cosec}4x}}{(2\ln\operatorname{cosec}4x)^2} \checkmark \checkmark \checkmark \checkmark \checkmark.$$

(5)

2.2.3
$$y = arc\sec(2.4^{3x})$$

$$\frac{dy}{dx} = \frac{6.4^{3x}\ln 4}{2.4^{3x}\sqrt{(2.4^{3x})^2 - 1}} \checkmark\checkmark$$

(2)

2.3
$$y = x^{e^x}$$
$$\ln y = e^x.\ln x \checkmark$$
$$\frac{1}{y}\frac{dy}{dx} = e^x.\ln x + \frac{e^x}{x} \checkmark\checkmark$$
$$\frac{dy}{dx} = x^{e^x}(e^x \ln x + \frac{e^x}{x}) \checkmark$$

(4)

2.4 2.4.1
$$12x^3 - 1y - x\frac{dy}{dx} = 3.2^{3x}\ln 2 \checkmark$$
$$\frac{12x^3 - y - 3.2^{3x}\ln 2}{x} = \frac{dy}{dx} \checkmark$$
$:$
$at(1,\text{-}5)$

$$\frac{dy}{dx} = \frac{12 - (-5) - 3.8\ln 2}{1}$$
$$\frac{dy}{dx} = 0{,}364 \checkmark$$

(3)

2.4.2
$$y = mx + c$$
$$-5 = 0{,}364(1) + c \checkmark$$
$$-5{,}364 = c \checkmark$$
$$equation: y = 0{,}364x - 5{,}364$$

(2)

[24]

QUESTION 3

3.1 3.1.1 $f(x) = x^3 - 5x - 4$

$3x^2 - 5 = 0$ ✓

$x = 1{,}291$ or $x = -1{,}291$ ✓mark for both x-values

$y = -8{,}303$ $y = 0{,}303$ ✓mark for both y-values (3)

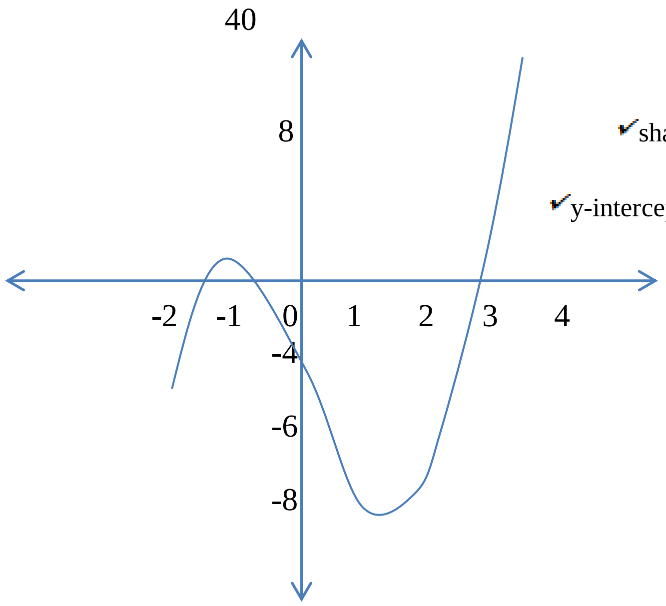
3.1.2 Use values on the table: $0 \le x \le 4$

X	0	1	2	3	4
Y	-4	-8	-6	8	40

✓✓✓ marks for any 4 correct values

y-value changes from negative to positive indicating a root ✓ (4)

3.1.3



✓shape of the graph

✓y-intercept

(2)

3.1.4

$$e = -\frac{f(2{,}7)}{f'(2{,}7)} = -\frac{2{,}183}{16{,}87} = -0{,}129$$ ✓ ✓ ✓

$a = 2{,}7 - 0{,}129 = 2{,}571$ ✓ (4)

3.2 3.2.1

$$A = xy$$
$$50 = xy \quad \checkmark$$
$$50x^{-1} = y$$

$$P = 2x + 100x^{-1} \quad \checkmark$$
$$\frac{dP}{dt} = 2\frac{dx}{dt} - \frac{100}{x^2}.\frac{dx}{dt} \quad \checkmark$$
$$\frac{dP}{dt} = 2(3) - \frac{100}{7^2}.3 \quad \checkmark$$
$$\frac{dP}{dt} = -0{,}122 \quad \checkmark$$

(5)

3.2.2

$$\frac{dP}{dt} = 0 \text{ only if } \frac{dx}{dt} = \frac{dy}{dt} \quad \checkmark$$

Therefore: $x=y$

Meaning the figure is a square ✓ (2)

3.3 3.3.1

$$s(t) = 3t^{\frac{1}{2}} - 3t^{\frac{3}{2}} - t^{\frac{5}{2}}$$
$$v = \frac{3}{2\sqrt{t}} - \frac{9}{2}t^{\frac{1}{2}} - \frac{5}{2}t^{\frac{3}{2}} \quad \checkmark\checkmark$$
$$v = -23{,}987 \quad \checkmark\checkmark$$

(4)

3.3.2

$$a = \frac{-3}{4t^{\frac{3}{2}}} - \frac{9}{4t^{\frac{1}{2}}} - \frac{15}{4}t^{\frac{1}{2}} \quad \checkmark\checkmark$$
$$a = -7{,}159 \quad \checkmark$$

(3)

[27]

QUESTION 4

4.1

$$\frac{(e^x + e^{-x})^5}{5} + c \quad ✓✓$$

(2)

4.2 4.2.1

$$y = \frac{\sin x}{\sqrt{1+\cos x}}$$

$$u = 1 + \cos x$$

$$dx = \frac{du}{-\sin x} \quad ✓$$

$$\int \frac{\sin x}{\sqrt{u}} . \frac{du}{-\sin x}$$

$$-\int u^{\frac{-1}{2}} du \quad ✓$$

$$-2u^{\frac{1}{2}} + c$$

$$-2\sqrt{1+\cos x} + c \quad ✓$$

(3)

4.2.2

$$y = x.\sec^2 x$$

$$f(x) = x \qquad g'(x) = \sec^2 x$$

$$f'(x) = 1 \qquad g(x) = \tan x \quad ✓$$

$$x.\tan x - \int \tan x dx$$

$$x.\tan x - \ln(\sec x) + c$$

✓ ✓

(3)

4.2.3

$$y = \cos 6x.\cos 2x$$

$$\int \cos(8x) + \cos(4x) dx$$

$$= \frac{\sin 8x}{8} + \frac{\sin 4x}{4} + c$$

✓ ✓

(2)

4.2.4

$$y = \frac{2}{3+4x^2}$$

$$\int \frac{2}{3+4x^2} dx \quad ✓$$

$$= \frac{2}{\sqrt{3}} \tan^{-1} \frac{x}{\sqrt{3}} + c$$

✓ ✓

(3)

4.3 $y = \dfrac{x^3 - 2}{x^2 + 2x}$

$$\frac{x^3 - 1}{(x)(x+2)} = \frac{A}{x} + \frac{B}{x+2}$$

$$x^3 - 1 = A(x+2) + Bx \quad \checkmark$$

$$x = -2 : \frac{9}{2} = B \quad \checkmark$$

$$x = 0 : -\frac{1}{2} = A \quad \checkmark$$

$$\int \frac{-\frac{1}{2}}{x} + \frac{\frac{9}{2}}{(x+2)}\, dx$$

$$= -\frac{1}{2}\ln x - \frac{9}{2}\ln(x+2) + c$$

$\checkmark \quad \checkmark$

(5)

4.4

$$= \int x + 5 + \frac{25}{x-5}\, dx \quad \checkmark\checkmark$$

$$= \frac{x^2}{2} + 5x + 25\ln(x-5) + c$$

$\checkmark \quad \checkmark$

(4)

[22]

QUESTION 5

5.1 5.1.1

$$\int_0^4 \sqrt{16-x^2} - (4-x)dx \quad ✓$$

$$= [8\sin^{-1}\frac{x}{4} + \frac{x}{2}\sqrt{16-x^2} - 4x + \frac{x^2}{2}]_0^4 \quad ✓$$

$$= (4{,}566-0)$$

$$= 4{,}566 \quad ✓$$

(3)

5.1.2

$$\pi\int_0^4 \sqrt{16-x^2}^{\,2} - (4-x)^2 dx \quad ✓$$

$$= \pi[16x - \frac{x^3}{3} - 16x + \frac{8x^2}{2} - \frac{x^3}{3}]_0^4 \quad ✓✓$$

$$= \pi[(21{,}333) - (0)]$$

$$= 67{,}02 \quad ✓$$

(4)

5.2 .

$$= -5[\frac{e^{-st}}{-s}]_0^{\infty} \quad ✓$$

$$= \frac{5}{s}[\frac{1}{e^{st}}]_0^{\infty} \quad ✓$$

$$= \frac{5}{s}(0-1) \quad ✓$$

$$= \frac{-5}{s} \quad ✓$$

(4)
[11]

QUESTION 6

6.1

$$\frac{dy}{dx} = \frac{\tan^2 y}{\mathrm{cosec}^2 x}$$

$$\frac{1}{\tan^2 y} dy = \frac{1}{\mathrm{cosec}^2 x} dx \quad ✓$$

$$\cot^2 y dy = \sin^2 x dx$$

$$✓(\mathrm{cosec}^2 y - 1) dy = (\frac{1}{2} - \frac{1}{2}\cos 2x) dx \quad ✓$$

$$-\cot y - y = \frac{1}{2}x - \frac{\sin 2x}{4} + c \quad ✓ ✓$$

(4)

6.2 ✓

$$\frac{dy}{dx} = \frac{-1x^3}{6} + \frac{3x^2}{4} + \pi x + c \quad ✓$$

$$y = \frac{-x^4}{24} + \frac{3x^3}{12} + \frac{\pi x^2}{2} + cx + d$$

$$-3 = 3{,}725 + c \quad ✓$$

$$-6{,}725 = c$$

$$2 = -4{,}946 + d$$

$$6{,}946 = d \quad ✓$$

(5)
[9]

TOTAL: 100

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