MATH142 Formula Sheet: Final Exam

Polar Coordinates:

$$r = \sqrt{x^2 + y^2}$$

 $\theta = \tan^{-1}(\frac{\pi}{2})$ [chosen appropriately]
 $x = r \cos \theta$
 $y = r \sin \theta$

Area in Polar Coordinates:

$$A = \frac{1}{2} \int_{0}^{\theta} (f(\theta))^{2} d\theta = \frac{1}{2} \int_{0}^{\theta} r^{2} d\theta$$

Arc Length:

Cartesians:
$$S = \int_{a}^{b} \sqrt{1 + \left(\frac{dy}{dx}\right)^2} dx$$

Parametric: $S = \int_{a}^{s} \sqrt{\left(x'(t)\right)^2 + \left(y'(t)\right)^2} dt$
Polar coordinates: $S = \int_{a}^{a_2} \sqrt{\left(\frac{dr}{d\theta}\right)^2 + r^2} d\theta$

Volumes of solids of revolution

Disc Method:
$$V = \pi \int_a^b [f(x)]^2 dx$$

Shell Method: $V = 2\pi \int_a^b x f(x) dx$

Elementary rules for Numerical Integration:

Midpoint:
$$\int_{a}^{b} f(x) dx \approx (b-a)f\left(\frac{a+b}{2}\right)$$

Trapezoidal: $\int_{a}^{b} f(x) dx \approx \frac{1}{2}(b-a)[f(a) + f(b)]$

$$\int_{a}^{b} f(x) dx \approx \frac{1}{3} \left(\frac{b-a}{2} \right) \left[f(a) + 4f \left(\frac{a+b}{2} \right) + f(b) \right]$$

with term test: If $\lim u_n \neq 0$, $\sum u_n$ diverges.

Geometric series:
$$\sum_{n=0}^{\infty} ar^n$$
, convergent for $|r| < 1$. If convergent, sum $S = \frac{a}{1-r}$.

$$p$$
-series: $\sum_{n=1}^{\infty} \frac{1}{n^p}$, convergent for $p > 1$.

"Telescoping" series:
$$\sum_{n=1}^{\infty} u_n$$
 where u_n can be written as a difference like $v_n - v_{n+1}$.

For
$$\sum_{n=1}^{\infty} u_n$$
, if $\sum_{n=1}^{\infty} c_n$ converges and $\sum_{n=1}^{\infty} d_n$ diverges,

CRT:
$$\lim_{n\to\infty} \frac{w_n}{c_n}$$
 finite gives convergence:
 $\lim_{n\to\infty} \frac{w_n}{d} > 0$ and finite gives divergence.

CT:
$$u_n \le c_n$$
 gives convergence; $u_n \ge d_n$ gives divergence.

RT: With
$$l = \lim_{n \to \infty} \left| \frac{u_{n+1}}{u_n} \right|$$
. $l < 1$ gives convergence, $l > 1$ gives divergence, $l = 1$ is inconclusive.

AST:
$$\sum_{m=1}^{\infty} u_m$$
 converges when $(i) \lim_{m \to \infty} |u_m| = 0$, and $(ii) \lim_{m \to \infty} |u_m| = 0$, and $(iii) \lim_{m \to \infty} |u_m| = 0$.

Taylor Series:
$$f(x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)(x-a)^n}{n!}$$

Maclaurin Series:
$$f(x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(0)x^n}{n!}$$

Composite rules for Numerical Integration:

Trapezoidal rule:
$$\int_{a}^{b} f(x) dx = \frac{1}{2}h \left\{ f(a) + 2f(a+h) + 2f(a+2h) + \cdots + 2f(a+[N-1]h) + f(b) \right\}, h = \frac{b-a}{m}$$

$$\int_a^b f(x) dx \approx \frac{1}{3}h \left\{ f(a) + 4f(a+h) + 2f(a+2h) + 4f(a+3h) + \dots + 2f(a+[N-2]h) + 4f(a+[N-1]h) + f(b) \right\}$$

Trigonometric Identities:

$$\sin[\theta \pm \phi] = \sin \theta \cos \phi \pm \cos \theta \sin \phi$$

 $\cos(\theta \pm \phi) = \cos \theta \cos \phi \mp \sin \theta \sin \phi$
 $\sin 2\theta = 2 \sin \theta \cos \theta$
 $\cos 2\theta = \cos^2 \theta - \sin^2 \theta$
 $1 = \cos^2 \theta + \sin^2 \theta$
 $\sinh(x \pm y) = \sinh x \cosh y \pm \cosh x \sinh y$
 $\cosh(x \pm y) = \cosh x \cosh y \pm \sinh x \sinh y$
 $\cosh(x \pm y) = \cosh^2 x + \sinh^2 x$
 $1 = \cosh^2 x - \sinh^2 x$

Hyperbolic Functions:

$$\cosh x = \frac{e^x + e^{-x}}{2}$$

$$\sinh x = \frac{e^x - e^{-x}}{2}$$

To establish convergence or divergence of a series, suggested test to try first:

$$u_n = \frac{\text{polynomial}}{\text{polynomial}} \longrightarrow \text{CRT}$$
 $u_n = \frac{\ln n}{\text{polynomial}} \longrightarrow \text{CRT or CT (using } \ln n < n)$
 $u_n \text{ contains } n! \longrightarrow \text{RT}$
 $u_n \text{ contains } c^n \longrightarrow \text{RT (or CT)}$
 $u_n = \frac{\text{trig function}}{\text{polynomial}} \longrightarrow \text{CT}$
 $u_n = \frac{\text{CRT on } |u_n| \text{ then AST only if necessary } n$

$$u_n = (-1)^n \frac{\text{polynomial}}{\text{polynomial}} \longrightarrow \text{CRT on } |u_n| \text{ then AST only if necessary}$$

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