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DEPT. OF MATH. EDUCATION
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p109 39. HYPERBOLIC F·ts

def) $\sinh z = \frac{e^z - e^{-z}}{2}$

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

* $\frac{d}{dz}\sinh z = \frac{e^z + e^{-z}}{2} = \cosh z$

$\frac{d}{dz}\cosh z = \frac{e^z - e^{-z}}{2} = \sinh z$

* $-i\sinh(iz) = -i\,\frac{e^{iz} - e^{-iz}}{2}$

$= \frac{e^{iz} - e^{-iz}}{2i}$

$\frac{-i}{2} = \frac{1}{2i}$

$-2i^2 = 2$

$2 = 2$

$= \sin z$

$\cosh(iz) = \frac{e^{iz} + e^{-iz}}{2} = \cos z$

$$* \ -i\sin(iz) = -i\left(\frac{e^{i(iz)} - e^{-i(iz)}}{2i}\right)$$

$$= -\frac{e^{-z} - e^{z}}{2}$$

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

$$\cos(iz) = \frac{e^{i(iz)} + e^{-i(iz)}}{2}$$

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

$$* \ \sinh z = \underbrace{\sinh x \cos y}_{u(x,y)} + i\,\underbrace{\cosh x \sin y}_{v(x,y)}$$

$$\left(\because \ \sinh z = \frac{e^{z} - e^{-z}}{2}\right.$$

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

복소 17 (9-1)

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$$= \frac{1}{2}\left(e^{x}(\cos y + i\sin y) - e^{-x}(\cos y - i\sin y)\right)$$

$$= \left(\left(\frac{e^{x}-e^{-x}}{2}\right)\cos y + i\left(\frac{e^{x}+e^{-x}}{2}\right)\sin y\right)$$

$* \cosh z = \cosh x \cos y + i \sinh x \sin y$

$$\left(\because \cosh z = \frac{e^{z}+e^{-z}}{2}\right.$$

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

$$= \frac{1}{2}\left(e^{x}(\cos y + i\sin y) + e^{-x}(\cos y - i\sin y)\right)$$

$$= \left(\frac{e^{x}+e^{-x}}{2}\right)\cos y + i\left(\frac{e^{x}-e^{-x}}{2}\right)\sin y$$

$$= \underbrace{\cosh x \cos y}_{u(x,y)} + i\underbrace{\sinh x \sin y}_{v(x,y)}$$

전함수

$$\begin{cases} u_x = v_y = \sinh x \cos y \\ v_x = -u_y = \cosh x \sin y \end{cases} \quad ; \text{C-R-Eqs OK}$$

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$*\ \cosh z = \cosh x \cos y + i \sinh x \sin y$

$|\cosh z|^2 = \underbrace{\cosh^2 x}_{1+\sinh^2 x} \cos^2 y + \sinh^2 x \sin^2 y$

ㄴ 실수부 제곱 + 허수부 제곱

$= \cos^2 y + \sinh^2 x (\underbrace{\cos^2 y + \sin^2 y}_{=1})$

$= \sinh^2 x + \cos^2 y$

$\therefore |\cosh z| = \sqrt{\sinh^2 x + \cos^2 y}$

$\therefore \cosh z = 0 \iff \sinh x = 0 \ \&\ \cos y = 0$

$\iff x = 0,\ y = (n+\frac{1}{2})\pi,\ n \in \mathbb{Z}$

$\therefore z = i(n+\frac{1}{2})\pi \quad (n \in \mathbb{Z})$

p110

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$$* \sinh z = \sinh x \cos y + i \cosh x \sin y$$

$$|\sinh z|^2 = \sinh^2 x \cos^2 y + \underbrace{\cosh^2 x}_{\downarrow \; 1+\sinh^2 x} \sin^2 y$$

$$= \sin^2 y + \sinh^2 y \, (\underbrace{\cos^2 y + \sin^2 y}_{= 1})$$

$$= \sinh^2 x + \sin^2 y$$

$$\therefore \; |\sinh z| = \sqrt{\sinh^2 x + \sin^2 y}$$

$$\& \; \sinh z = 0 \iff \sinh x = 0 \;\; \& \; \sin y = 0$$

$$\iff x = 0, \;\; y = n\pi, \;\; (n \in \mathbb{Z})$$

def) $\tanh z = \dfrac{\sinh z}{\cosh z}$, $\coth z = \dfrac{\cosh z}{\sinh z}$

$\operatorname{sech} z = \dfrac{1}{\cosh z}$, $\operatorname{csch} z = \dfrac{1}{\sinh z}$

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* $\frac{d}{dz}\tanh z = \frac{d}{dz}\left(\frac{\sinh z}{\cosh z}\right)$

$$= \frac{\cosh^2 z - \sinh^2 z}{\cosh^2 z} = \frac{1}{\cosh^2 z}$$

P111 EX

$$= \operatorname{sech}^2 z$$

#6 #7 #9 #10

#12 #16 #17

40. Inverse Trigonometric Hyperbolic Fts

def) $w = \sin^{-1} z$ iff $\sin w = z$

$$z = \sin w = \frac{e^{iw} - e^{-iw}}{2i}$$

양쪽에 2i 곱

e에 대한 이차식으로

$$\Leftrightarrow e^{2iw} - 2iz e^{iw} - 1 = 0$$

↓ 근의 공식 use

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$$\Rightarrow e^{iw} = \frac{2iz+(4-4z^2)^{\frac{1}{2}}}{2} = iz+(1-z^2)^{\frac{1}{2}}$$

$$\therefore \ w = -i\log\left(iz+(1-z^2)^{\frac{1}{2}}\right)$$

; Multi - Valued.

p113

EX) $\sin^{-1}(-i) = ?$

(sol) $\sin^{-1}(-i) = -i\log\left(i(-i)+(1-(-i)^2)^{\frac{1}{2}}\right)$

$$= -i\log\left(1+(2)^{\frac{1}{2}}\right)$$

$$= -i\log(1\pm\sqrt{2})$$

$$= -i\log(1+\sqrt{2}) \text{ or } -i\log(1-\sqrt{2})$$

$\frac{1}{\sqrt{2}+1} = \sqrt{2}-1$ $\quad = -i\left(\ln(1+\sqrt{2})+2n\pi i\right)$

$$\text{or } -i\left(\underbrace{\ln(\sqrt{2}-1)}_{-\ln(\sqrt{2}+1)}+(2n+1)\pi i\right) \ (n\in\mathbb{Z})$$

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$= -i\left(\ln(1+\sqrt{2}) + 2n\pi i\right)$ or

$-i\left(-\ln(1+\sqrt{2}) + (2n+1)\pi i\right) \quad (n \in \mathbb{Z})$

$= -i\left((-1)^n \ln(1+\sqrt{2}) + n\pi i\right) \quad (n \in \mathbb{Z})$

$= n\pi + i(-1)^{n+1} \ln(1+\sqrt{2}) \quad (n = 0, \pm 1, \pm 2, \cdots)$

Quiz) $\sin^{-1}(2i) = ?$

21836236 박다영 복소 퀴즈 17

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5. 11. 월.

(Quiz) $\sin^{-1}(2i) = ?$

(sol) $\sin^{-1}(2i) = -i \log\left[i(2i) + (1-\overset{4i^2}{(2i)^2})^{\frac{1}{2}}\right]$

$= -i \log\left[-2 + (1+4)^{\frac{1}{2}}\right]$

$= -i \log(-2 \pm \sqrt{5})$

$= -i \log(-2+\sqrt{5})$ or $-i \log(-2-\sqrt{5})$

$= -i(\ln(-2+\sqrt{5}) + 2n\pi i)$

$\frac{1}{\sqrt{5}-2}$ or $-i(\ln(+2+\sqrt{5}) + (2n+1)\pi i)$

$= \sqrt{5}+2$ $= -i(-\ln(2+\sqrt{5}) + 2n\pi i)$ $(n \in \mathbb{Z})$

or $-i \ln(2+\sqrt{5}) + (2n+1)\pi i)$ $(n \in \mathbb{Z})$

$= -i((-1)^n \ln(2+\sqrt{5}) + n\pi i)$ $(n \in \mathbb{Z})$

$= n\pi + i(-1)^{n+1} \ln(2+\sqrt{5})$ $(n = 0, \pm 1, \pm 2 \ldots)$

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def) $w = \cos^{-1} z$ iff $\cos w = z$

$$z = \cos w = \frac{e^{iw} + e^{-iw}}{2}$$

$$\Leftrightarrow e^{2iw} - 2z e^{iw} + 1 = 0$$

$$\Rightarrow e^{iw} = \frac{2z + (4z^2 - 4)^{\frac{1}{2}}}{2}$$

$$= z + (z^2 - 1)^{\frac{1}{2}}$$

$$\therefore w = -i \log\left(z + (z^2 - 1)^{\frac{1}{2}}\right)$$

$*$ $w = \tan^{-1} z \Leftrightarrow \tan w = z$

$$\Leftrightarrow z = \frac{\sin w}{\cos w}$$

$$=$$

$$= \frac{\frac{e^{iw} - e^{-iw}}{2i}}{\frac{e^{iw} + e^{-iw}}{2}}$$

$$= \frac{e^{2wi} - 1}{i(e^{2iw} + 1)}$$

$$\Rightarrow e^{2iw} = \frac{-2i-1}{2i-1} = \frac{-z+i}{z+i}$$

$$\Rightarrow w = \frac{1}{2i} \log\left(\frac{i-z}{i+z}\right) = \frac{i}{2} \log\left(\frac{i-z}{i+z}\right)$$

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$$* \ \frac{d}{dz}\sin^{-1}z = \frac{1}{(1-z^2)^{\frac{1}{2}}}$$

$$\left(\because \quad w = \sin^{-1} z \Leftrightarrow \sin w = z \right.$$

Diff at $\cos w \dfrac{dw}{dz} = 1$

$$\Rightarrow \frac{dw}{dz} = \frac{d}{dz}(\sin^{-1}z) = \frac{1}{\cos w}$$

$$(\cos^2 w + \sin^2 w = 1)$$

$$= \frac{1}{(1-\sin^2 w)^{\frac{1}{2}}}$$

$$\left. = \frac{1}{(1-z^2)^{1/2}} \right)$$

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* $\frac{d}{dz}\cos^{-1}z = -\frac{1}{(1-z^2)^{1/2}}$

$\left(\because \frac{d}{dz}\tan^{-1}z = \frac{1}{1+z^2} \right.$

$w = \tan^{-1}z \Leftrightarrow \tan w = z$

Diff. at $\sec^2 w \frac{dw}{dz} = 1$

$\left. \Rightarrow \frac{dw}{dz} = \frac{1}{\sec^2 w} = \frac{1}{\tan^2 w+1} = \frac{1}{z^2+1} \right)$

* $\sinh^{-1}z = \log\left(z+(z^2+1)^{\frac{1}{2}}\right)$

$(\because \; w = \sinh^{-1}z \Leftrightarrow \sinh w = z$

$\Leftrightarrow \frac{e^w - e^{-w}}{2} = z$

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$$\Leftrightarrow e^{2w} - 2z e^{w} - 1 = 0$$

$$\therefore e^{w} = \frac{2z + (4z^2+4)^{\frac{1}{2}}}{2}$$

$$= z + (z^2+1)^{1/2}$$

$$\therefore w = \sinh^{-1} z$$

$$= \log\left(z + (z^2+1)^{\frac{1}{2}}\right) \Big)$$

$$* \cosh^{-1} z = \log\left(z + (z^2-1)^{\frac{1}{2}}\right)$$

$$\Big(\because w = \cosh^{-1} z \Leftrightarrow \cosh w = z$$

$$\Leftrightarrow \frac{e^{w} + e^{-w}}{2} = z$$

$$\Leftrightarrow e^{2w} - 2z e^{w} + 1 = 0$$

복소 17

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$$e^w = \frac{2z+(4z^2-4)^{\frac{1}{2}}}{2}$$

$$= z+(z^2-1)^{\frac{1}{2}}$$

$$\therefore w = \log\left(z+(z^2-1)^{\frac{1}{2}}\right)$$

$$\therefore w = \sinh^{-1} z$$

$$= \log\left(z+(z^2+1)^{\frac{1}{2}}\right)$$

//

복소 (8)

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5. 18. 월.

$* \ \sinh^{-1} z = \log(z + (z^2+1)^{1/2})$

$(\because \ w = \sinh^{-1} z \Leftrightarrow \sinh w = z$

$\Leftrightarrow \dfrac{e^w - e^{-w}}{2} = z$

$\Leftrightarrow e^{2w} - 2z e^w - 1 = 0$

$\Rightarrow e^w = \dfrac{2z + (4z^2+4)^{1/2}}{2}$

$= z + (z^2+1)^{1/2}$

$* \ \cosh^{-1} z = \log(z + (z^2-1)^{1/2})$

let $w = \cosh^{-1} z \Leftrightarrow \cosh w = z$

$\Leftrightarrow \dfrac{e^w + e^{-w}}{2} = z$

$\Leftrightarrow e^{2w} - 2z e^w + 1 = 0$

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5 18. 월.

$$\Rightarrow e^{w} = \frac{2z + (4z^2 - 4)^{\frac{1}{2}}}{2}$$

$$\therefore w = \log\left(z + (z^2-1)^{1/2}\right)$$

$$* \tanh^{-1} z = \frac{1}{2}\log\left(\frac{1+z}{1-z}\right)$$

$$\left(\because w = \tanh^{-1} z \Leftrightarrow \tanh w = z\right.$$

$$\Leftrightarrow \frac{e^{2w}-1}{e^{2w}+1} = z$$

Exercise *1 *2 *3

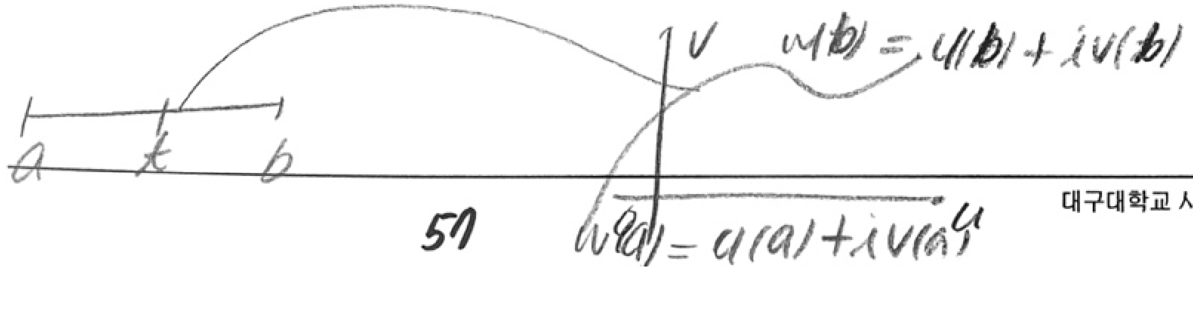
4 ~ 7은 했음

Chapter 4 Integrals p115

41 Deriv. of fts $w(t) = u(t) + iv(t)$

* 1 - parameter complex ft ;

$w(t) = u(t) + iv(t) \quad (t \in \mathbb{R})$



복소 18

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5 18 수.

$w'(t) = \frac{d}{dt} w(t) = u'(t) + i v'(t)$

(ex) $\frac{d}{dt} e^{z_0 t}$ $(z_0 = x_0 + i y_0 \in \mathbb{C})$

$= \frac{d}{dt} e^{x_0 t + i y_0 t}$

$= \frac{d}{dt} (e^{x_0 t})(e^{i y_0 t})$

$= x_0 e^{x_0 t} \cdot e^{i y_0 t} + i y_0 e^{x_0 t} e^{i y_0 t}$

$= (x_0 + i y_0) e^{(x_0 + i y_0) t}$

$= z_0 e^{z_0 t}$

< 복소의 미분에서 다른 점 - M-V-T를 항상 만족하지는 X >

(EX) (M-V-T : Not always True
in Complex ft ; $w(t) = u(t) + i v(t)$)

복소18

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5.18.수.

$w(t) = e^{it} = \underbrace{\cos t}_{u(t)} + i\underbrace{\sin t}_{v(t)} \quad (0 \le t \le 2\pi)$

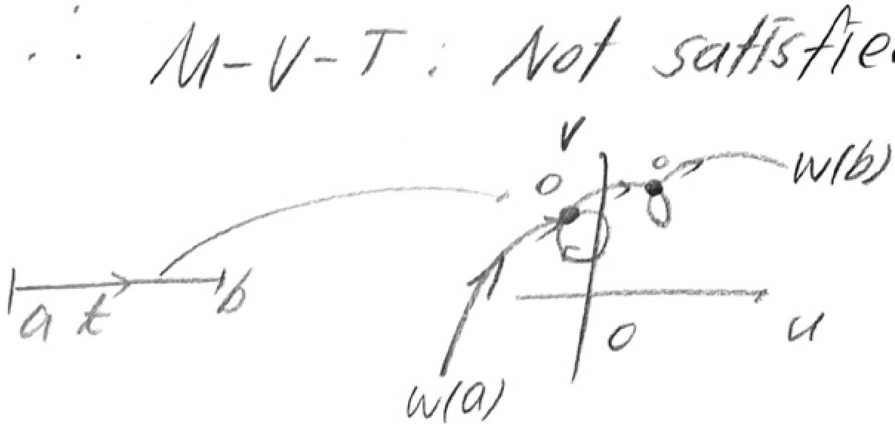
since $w(t) = ie^{it}$ $t \in [0, 2\pi]$

$\Rightarrow |w(t)| = |ie^{it}| = 1 \quad t \in [0, 2\pi]$

$\therefore \nexists\, t_1$ in $[0, 2\pi]$

$(\because w(t_1) \neq \dfrac{w(2\pi) - w(0)}{2\pi - 0} = \dfrac{1-1}{2\pi} = 0$ 값다름이용.

$\therefore$ M-V-T : Not satisfied



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5 18. 4.

42 Definite Integrals of f.ts (정적분)

$w(t) = u(t) + i\,v(t)$.

def) Definite integral of $w(t) = u(t) + iv(t)$

on $a \le t \le b$:

$$\Leftrightarrow \int_a^b w(t)\,dt = \int_a^b u(t)\,dt + i\int_a^b v(t)\,dt$$

(Ex) $$\int_0^1 \underbrace{(1+it)^2}_{w(t)} dt = \int_0^1 (1-t^2+2it)\,dt$$

방법 ①

$$= \int_0^1 (1-t^2)\,dt + i\int_0^1 2t\,dt$$

$$= \left[t - \frac{t^3}{3}\right]_0^1 + i\left[t^2\right]_0^1 = \frac{2}{3} + i \;_{//}$$

방법 ② put $K = 1+it$. $\Rightarrow dK = i\,dt$

$\downarrow$

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5 18. 수.

$$\int_1^{1+i} k^2(-i\,dk) = -i\int_1^{1+i} k^2 dk$$

$$= -i\left[\frac{k^3}{3}\right]_{k=1}^{k=1+i} \;_{//}$$

* (Fundamental Thm of Calculus - F.T.C) (미적분학 기본정리)

for $w(t) = u(t) + iv(t)$

let U, V : Indefinite integrals of u, v

$\Rightarrow W = U + iV$: Indefinite integral of "w" s.t $W' = w$

& $\displaystyle\int_a^b w(t)\,dt = \int_a^b u(t)\,dt + i\int_a^b v(t)\,dt$

$= U\Big|_a^b + i\,V\Big|_a^b$

$= W\Big|_a^b$

복소 18

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38453 경북 경산시 진량읍 대구대로 201
DAEGU UNIVERSITY
DEPT. OF MATH. EDUCATION
201 DAEGUDAE-RO, JINRYANG-UP, KYEONGSAN-CITY,
KYEONGBUK, 38453, KOREA
TEL : (053)850-4210 FAX : (053)850-4211

5. 18. 수.

(ex) $\int_0^{\frac{\pi}{4}} e^{it}\,dt = ?$

(sol) $e^{it} = \underbrace{\cos t}_{u(t)} + i\underbrace{\sin t}_{v(t)}$

since $\underbrace{\sin t}_{U(t)}, \underbrace{-\cos t}_{V(t)}$: Anti-Deriv of $\cos t, \sin t$

$U + iV = \sin t - i\cos t$

$= -i(\cos t + i\sin t)$

$= -ie^{it} = W(t)$

$\therefore \int_0^{\frac{\pi}{4}} e^{it}\,dt = \left[-ie^{it}\right]_{t=0}^{t=\frac{\pi}{4}}$

$= -ie^{\frac{\pi}{4}i} - i = -i\left(\frac{1}{\sqrt{2}} + \frac{i}{\sqrt{2}}\right) + i$

복소 18)

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5. 18. 수.

* f: Conti on [a.b]

$$\Rightarrow f(c) = \frac{1}{b-a}\int_a^b f(x)\,dx \quad c \in [a.b]$$

; M-V-T for Integrals

(EX) (M-V-T for Integrals ; Not always True for $w(t) = u(t) + i\,v(t)$)

let $w(t) = e^{it}$ $(0 \le t \le 2\pi)$

$$\int_0^{2\pi} e^{it}\,dt = -i\left[e^{it}\right]_0^{2\pi}$$

$$= -i\left[1-1\right] = 0$$

But $|e^{it}| = 1$ $\forall t \in [0, 2\pi]$

$$e^{it} \neq \frac{1}{2\pi-0}\int_0^{2\pi} e^{it}\,dt = 0$$

$\forall t \in [0, 2\pi]$

$\therefore$ M-V-T for Integral

; Not Satisfied

 21836236 박다영

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5.18.수.

Quiz) $\int_0^\infty e^{-zt}\,dt = \frac{1}{z}$ $(\operatorname{Re} z > 0)$ "증명"

(pf) put $z = x + iy$

$$\Rightarrow \int_0^\infty e^{(-x-iy)t}\,dt$$

$$= \lim_{c\to\infty} \int_0^c e^{-xt} \cdot e^{-iyt}\,dt$$

여기서 $u(t)$. $v(t)$ 분리를 어떻게

해야 할 지 모르겠습니다 ...

적 그 - ∫ 적.미 인지 ??

복소 18 (중간 이후 첫수업)

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5.21.목.

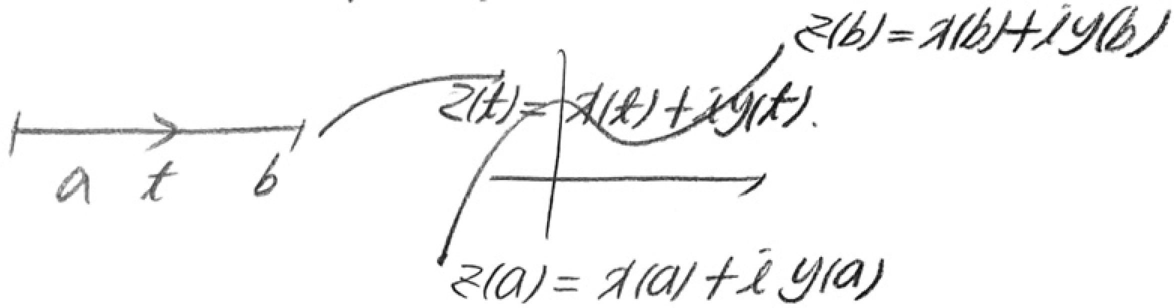
43 Contours

p 120

def) A set of pts $z=(x,y)$: arc (호)
└ 곡선

$\Leftrightarrow$ $x = x(t)$. $y = y(t)$

$(a \le t \le b)$: Conti



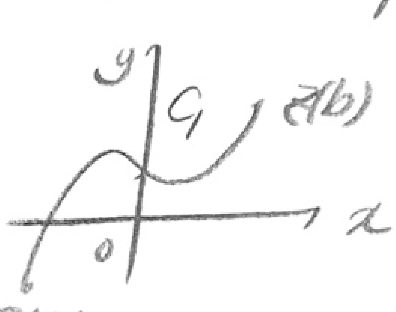
def) The arc $C : z(t) = x(t) + i\,y(t)$ $(a \le t \le b)$

C. simple arc or (Jordan arc)

단순곡선 → 즉 꼬이지 X

$\Leftrightarrow$ No Cross Point itself

(ex)



C_1 : Simple arc

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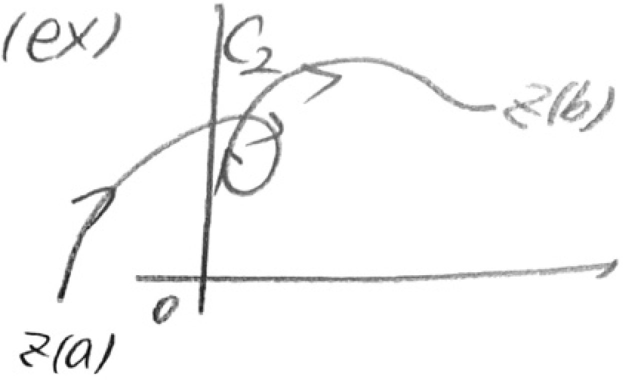
5. 22 금.

(ex)



C_2 : Not simple arc.

def) The arc $C: z(t) = x(t) + iy(t)$

$(a \le t \le b)$

: simple closed curve

or simple closed contour

$\Leftrightarrow$ C: simple curve except for $z(a) = z(b)$

C: simple closed curve

(단순폐곡선)

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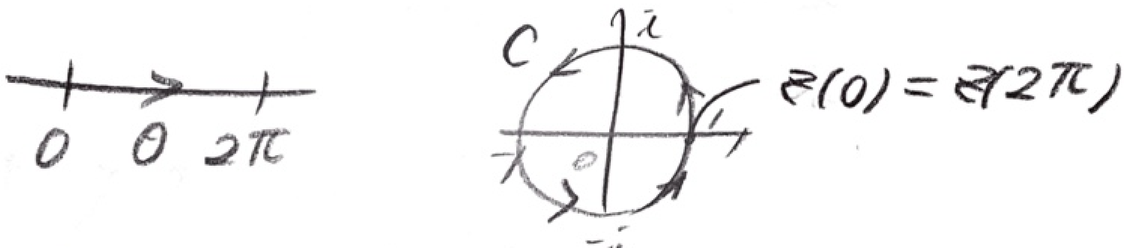
5. 22. 금.

(ex)

C : closed curve but Not simple

Ex) $C: z = e^{i\theta}$ $(0 \le \theta \le 2\pi)$



C : simple closed curve

def) ① $C: z(t)$ $(a \le t \le b)$

; Contour

$\Leftrightarrow$ C : piecewise smooth arc

(C : $z(t)$, $z(t)$: conti

$z'(t)$: piecewise conti)

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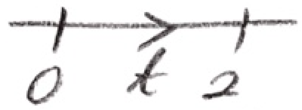
5. 22. 금.

(ii) $C: z(t)\ (a \le t \le b)$

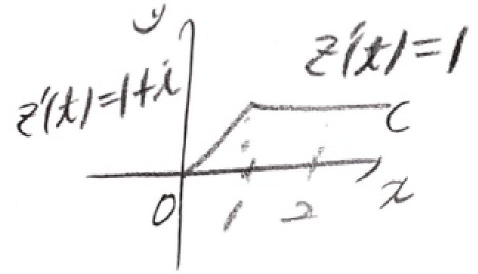
; simple closed contour

$\Leftrightarrow$ C: simple arc except for $z(a) = z(b)$

(EX) $z = \begin{cases} x + ix, & 0 \le x \le 1 \\ x + i, & 1 \le x \le 2 \end{cases}$



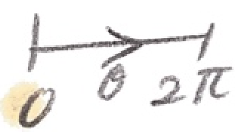
$t = x$

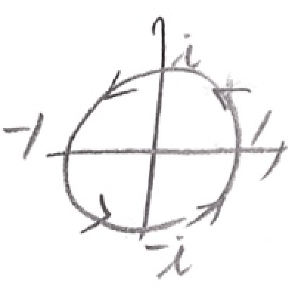


C: simple arc

; Contour & Not Closed

(EX) $C: z = e^{i\theta}, (0 \le \theta \le 2\pi)$





C: Simple Closed Contour