

## Chapter 3

### SECTION 29

1. (a)  $\exp(2 \pm 3\pi i) = e^2 \exp(\pm 3\pi i) = -e^2$ , since  $\exp(\pm 3\pi i) = -1$ .

(b) 
$$\begin{aligned} \exp \frac{2 + \pi i}{4} &= \left( \exp \frac{1}{2} \right) \left( \exp \frac{\pi i}{4} \right) = \sqrt{e} \left( \cos \frac{\pi}{4} + i \sin \frac{\pi}{4} \right) \\ &= \sqrt{e} \left( \frac{1}{\sqrt{2}} + i \frac{1}{\sqrt{2}} \right) = \sqrt{\frac{e}{2}} (1 + i). \end{aligned}$$

(c)  $\exp(z + \pi i) = (\exp z)(\exp \pi i) = -\exp z$ , since  $\exp \pi i = -1$ .

3. First write

$$\exp(\bar{z}) = \exp(x - iy) = e^x e^{-iy} = e^x \cos y - i e^x \sin y,$$

where  $z = x + iy$ . This tells us that  $\exp(\bar{z}) = u(x, y) + iv(x, y)$ , where

$$u(x, y) = e^x \cos y \quad \text{and} \quad v(x, y) = -e^x \sin y.$$

Suppose that the Cauchy-Riemann equations  $u_x = v_y$  and  $u_y = -v_x$  are satisfied at some point  $z = x + iy$ . It is easy to see that, for the functions  $u$  and  $v$  here, these equations become  $\cos y = 0$  and  $\sin y = 0$ . But there is no value of  $y$  satisfying this pair of equations. We may conclude that, since the Cauchy-Riemann equations fail to be satisfied anywhere, the function  $\exp(\bar{z})$  is not analytic anywhere.

4. The function  $\exp(z^2)$  is entire since it is a composition of the entire functions  $z^2$  and  $\exp z$ ; and the chain rule for derivatives tells us that

$$\frac{d}{dz} \exp(z^2) = \exp(z^2) \frac{d}{dz} z^2 = 2z \exp(z^2).$$

Alternatively, one can show that  $\exp(z^2)$  is entire by writing

$$\begin{aligned} \exp(z^2) &= \exp[(x + iy)^2] = \exp(x^2 - y^2) \exp(i2xy) \\ &= \underbrace{\exp(x^2 - y^2) \cos(2xy)}_u + i \underbrace{\exp(x^2 - y^2) \sin(2xy)}_v \end{aligned}$$

and using the Cauchy-Riemann equations. To be specific,

$$u_x = 2x \exp(x^2 - y^2) \cos(2xy) - 2y \exp(x^2 - y^2) \sin(2xy) = v_y,$$

and

$$u_y = -2y \exp(x^2 - y^2) \cos(2xy) - 2x \exp(x^2 - y^2) \sin(2xy) = -v_x.$$

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