計算題應詳列計算過程，無計算過程者不予計分

1. **Geometric series, 40 points.** Consider the following series:

$$\sum_{i=1}^{n} e^{-ix} = e^{-x} + e^{-2x} + \ldots + e^{-nx}$$

where $x > 0$.

(a) Simplify the above geometric series. (Hint: $\sum_{i=0}^{n-1} e^{-ix} = \frac{1-e^{-nx}}{1-e^{-x}}$.)

(b) Find the limit of the above series when $n \to +\infty$.

(c) How does the limit of this series change with x? Explain.

(d) Evaluate your answer in part (b) when $x \to 0$ and when $x \to +\infty$. Plot your results.

2. **Market concentration, 40 points.** According to the National Communications Commission (NCC), the number of mobile network subscribers in August 2020 is distributed as follows.

Operator	Number of subscribers
ChungHwa Telecom	10,555,342
Far EasTone Telecom	7,050,283
Taiwan Star Telecom	2,425,267
Taiwan Mobile	7,089,905
Asia Pacific Telecom	2,035,230

(a) Find the market share of every firm.

(b) Find the 4-firm concentration ratio, defined as the sum of market shares of 4 largest firms.

(c) Find the Herfindahl-Hirschman Index, which is the sum squares of all firms' market shares.

(d) Is the market concentrated? Explain your answer.

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3. **Advertising intensity, 20 points.** Consider the following advertising formula,

$$\frac{A}{pQ} = \frac{\varepsilon_A}{\varepsilon_D}$$

where A, p, and Q stands for advertising dollars, price, and output, respectively. In this context, $\varepsilon_A = \frac{\partial Q}{\partial A} \frac{A}{Q}$ ($\varepsilon_D = -\frac{\partial Q}{\partial p} \frac{p}{Q}$) represents the advertising (price, respectively) elasticity of demand.

(a) Does the firm advertise more or less when demand is more responsive to advertising?

(b) Does the firm advertise more or less when demand becomes more sensitive to price?

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