

Midterm 2

Full name:

Student number:

Class:

1. This exam consists of two parts. Part A consists of 12 multiple-choice questions and is worth 10 points. Part B consists of 2 open questions and is also worth 10 points.
2. Part A must be completed in 50 minutes and Part B in the remaining 40 minutes.
3. Indicate your answers to part A with an “X” in the table below. Each correct answer is worth 10/12 (≈ 0.83) points and each wrong answer is penalized by (10/12) / 3 (≈ 0.28) points.
4. Any kind of consultation is not allowed.
5. Turn off mobile phones, computers, tablets, and smartwatches. Their use will be considered fraud. The use of a non-graphical calculator is allowed.
6. Write your full name and student number on every answer sheet.
7. Return this answer sheet even if you withdraw from the exam.

ANSWER TABLE

1	2	3	4	5	6	7	8	9	10	11	12
a	a	a	a	a	a	a	a	a	a	a	a
b	b	b	b	b	b	b	b	b	b	b	b
c	c	c	c	c	c	c	c	c	c	c	c
d	d	d	d	d	d	d	d	d	d	d	d

English – Version A

PART A
MULTIPLE CHOICE (10 points / 50 min)

1. Consider the following pricing game between two competing cafés in Lisbon, A and B. Each café simultaneously chooses between setting a High price (H) or a Low price (L). Profits are given in the table below:

		Café B	
		H	L
Café A	H	4,4	1,5
	L	5,1	2,2

Which of the following statements is correct about the pure-strategy Nash equilibrium?

- a. The Nash equilibrium is (H, H).
- b. The Nash equilibrium is (L, L).**
- c. There are two Nash equilibria: (H, H) and (L, L).
- d. There is no Nash equilibrium.

2. Consider the following sequential quantity-setting game. Firm 1 moves first and chooses whether to produce a high quantity (H) or a low quantity (L). Firm 2 observes this choice and then chooses its own quantity (H or L). Payoffs (Firm 1, Firm 2) are as follows:

- If Firm 1 chooses H and Firm 2 chooses H: (1, 1)
- If Firm 1 chooses H and Firm 2 chooses L: (4, 2)
- If Firm 1 chooses L and Firm 2 chooses H: (2, 4)
- If Firm 1 chooses L and Firm 2 chooses L: (2, 2)

Which of the following correctly describes a subgame-perfect Nash equilibrium?

- a. Firm 1 chooses L, and Firm 2 chooses H after both H and L. This is subgame perfect since Firm 2 credibly signals it always chooses H.
- b. Firm 1 chooses H, and Firm 2 chooses H after both H and L. This is subgame perfect since H is a dominant strategy for Firm 1.
- c. Firm 1 chooses H, and Firm 2 chooses L after H and H after L. This is subgame perfect since Firm 2 chooses a rational action after each possible move by Firm 1.**
- d. There are two subgame-perfect Nash equilibria, since Firm 2 can either choose H or L depending on its attempt to influence Firm 1's decision.

3. Consider a sequential game in which Player 1 moves first and chooses between actions A or B. Player 2 then observes Player 1's choice and chooses between actions C or D. Which of the following statements correctly distinguishes between actions and strategies in this setting?

- a. A strategy for Player 2 is simply choosing either C or D.
- b. A strategy only needs to specify what a player does along the equilibrium path.

c. Actions and strategies are identical concepts in sequential games.

d. A strategy for Player 2 specifies an action for every possible action of Player 1, even if some of these actions are not reached in equilibrium.

4. In an oligopolistic market with two incumbent firms, a potential entrant is considering entering. Which of the following statements correctly explains why a threat of a “price war” by the incumbents may fail to deter entry?

a. Because the threat is not credible if, after entry occurs, the incumbent’s ex post optimal strategy is to accommodate the entrant.

b. Because the incumbent never lowers prices in any oligopoly model.

c. Because the entrant does not take the incumbent’s strategy into account when deciding whether to enter.

d. Because any entry automatically eliminates the incumbents’ profits.

5. Consider a sequential entry game where the incumbent firm is the follower, and the incumbent firm publicly declares that it will “respond aggressively” if the entrant decides to enter the market. Which of the following statements correctly identifies when such a threat can be considered credible in a subgame-perfect equilibrium?

a. When the incumbent announces forcefully enough that it will respond aggressively, regardless of what would be rational after entry.

b. When, in the subgame after entry, responding aggressively truly becomes the incumbent’s best response.

c. When the market has high entry costs, making entry more difficult, even though this does not change the incumbent’s preferences in the subgame.

d. The threat becomes credible whenever the incumbent prefers to maintain its market share at any cost, even if that response lowers its profit in the subgame after entry.

6. Consider an oil production cartel in which all firms coordinate on maintaining a high price. One of the firms is considering deviating by secretly lowering its price to gain market share, believing that its rivals will detect the deviation only later. The _____ of the cartel arises mainly because _____, which undermines the possibility of sustaining the _____ as an equilibrium. Which of the following combinations correctly fills in the blanks?

a. corporation; firms benefit from deviation; low price

b. corporation; of barriers to entry; this generates deviation; cartel

c. instability; firms benefit from deviation; cartel

d. instability; of large marginal costs; low price

7. Consider the provision of a public good such as national defence. Which of the following statements correctly characterizes the key economic features of a pure public good?

- a. A public good is rivalrous and excludable, which allows it to be efficiently provided through markets.
- b. A public good is non-rivalrous but excludable, which implies that firms can always profitably supply it at the efficient level.
- c. A public good is rivalrous but non-excludable, which implies that consumption by one individual prevents others from consuming it.
- d. A public good is non-rivalrous and non-excludable, which makes it difficult to charge individuals for their consumption and leads to under provision in markets.
8. In a monopolistically competitive market, firms can innovate in several dimensions. Which of the following statements best characterizes the role of innovation in this market?
- a. Firms innovate until the marginal private benefit of innovation equals the total social benefit, which guarantees dynamic efficiency.
- b. Innovation disappears in the long run, because entry forces all firms to return to the original undifferentiated product.
- c. There is always an incentive to innovate to raise profits in the short run, even though these profits may disappear in the long run due to firm entry
- d. The equilibrium level of innovation in the long run is greater than the socially optimal level, because firms innovate excessively to deter potential entrants.
9. Consider the following statement: “*In a market with free entry and product differentiation, long-run equilibrium is determined by the gradual erosion of the demand faced by each firm, as new competitors enter and also offer additional varieties.*” Which of the following options correctly classifies this statement as true or false, with the appropriate justification?
- a. True, because entry shifts each firm’s individual demand curve to the left until price equals average cost, implying low to zero profits.
- b. False, because differentiation always guarantees enough market power to maintain prices above average total costs, regardless of entry.
- c. False, because differentiation eliminates any effect of entry, preserving initial quantities and prices even when new firms enter.
- d. True, because in differentiated markets price inevitably converges to marginal cost, just as in perfectly competitive markets with zero economic profits.
10. Consider an economy with two individuals who derive benefits from a public good. Which of the following statements correctly describes how to determine the efficient level of a public good?
- a. The efficient level is determined by horizontally summing individual demand curves and setting this equal to marginal cost.
- b. The efficient level is determined by vertically summing individual marginal willingness to pay and setting this equal to marginal cost.
- c. The efficient level is determined by equating each individual’s marginal willingness to pay to marginal cost separately.

d. The efficient level is determined by averaging individual marginal willingness to pay and comparing it to marginal cost.

11. Consider a cartel formed by two identical firms competing in an oligopolistic market. The game between the firms is repeated infinitely over time, and in each period each firm chooses between “collude,” by maintaining a high price, or “deviate,” by cutting price to increase sales in that period. The firms perfectly observe past actions and adopt the following “trigger” strategy: each firm sticks to the collusive agreement as long as neither has deviated in the past, but after any deviation, both firms deviate forever. Which of the following statements is correct?

- a. Collusion is sustainable if firms care only about the present, because impatient firms avoid strategies involving future punishments.
- b. Collusion is sustainable, independent of whether firms care about the future, as long as the game is repeated infinitely many times.
- c. Collusion is sustainable only if firms care sufficiently about the future, because the present value of future losses from deviation exceed the short-run gain from deviation.
- d. Collusion can never be sustainable in repeated games, because deviation is always a dominant strategy.

12. Imagine a beach that is 1 km long, represented by the interval $[0,1]$. Tourists are uniformly distributed along the beach and want to buy bottled water. Each tourist buys one bottle and travels to the nearest seller, incurring a transportation cost proportional to the distance travelled. There are two sellers, A and B. The price of water is fixed and identical for both sellers. Thus, the sellers only compete in location along the beach. Each seller chooses its location simultaneously. Which of the following statements correctly describes the outcome of this model?

- a. The Nash equilibrium occurs when both sellers locate at the centre of the beach ($1/2$), but this location is not socially efficient, because minimizing the total distance would require the sellers to locate at $1/4$ and $3/4$.
- b. The Nash equilibrium occurs when the sellers locate at the two ends of the beach (0 and 1), which also minimizes the total distance travelled by consumers and is therefore socially optimal.
- c. The Nash equilibrium always coincides with the socially efficient solution ($1/2$), because location competition fully internalizes consumers’ transportation costs.
- d. There is no Nash equilibrium in pure strategies, because any common location can be improved upon by a unilateral deviation, and therefore the market is inefficient.

PART B
OPEN QUESTIONS (10 points / 40 min)

The following information describes the economic context for both questions:

Greenland has significant reserves of critical and strategic minerals, which are essential for green technologies, batteries, and advanced defence systems. Two major firms operate, or intend to operate, in the region:

- Firm 1: Arctic Minerals USA, a large North American company
- Firm 2: Nordic Strategic Mining DK, a Danish international firm

Question 1 (5 points)

For this question, consider that each firm can choose between two actions:

- H: a High extraction level
- L: a Low extraction level

Profits depend on the combination of extraction choices. The simultaneous move game is represented by the following payoff matrix, where payoffs are listed in the order (Firm 1, Firm 2):

		Firm 2	
		H	L
Firm 1	H	2,2	$x,3$
	L	3, y	4,4

a. Explain clearly what a dominant strategy is. Then determine for which values of x and y this game has a dominant strategy for each firm. State the dominant strategy of each firm. (1 point)

Suppose that $x = 5$ and $y = 5$ for the next two questions.

b. Determine all potential (both pure- and mixed-strategy) Nash equilibria of the simultaneous move game. (2 points)

c. Now the game is played sequentially. Firm 1 moves first and chooses either H or L. Firm 2 observes Firm 1's choice and then chooses its own action. Determine the subgame-perfect Nash equilibrium. Your answer must be written in strategies, not in terms of the equilibrium outcome. (2 points)

Question 2 (5 points)

For this question, consider that both firms extract the same homogeneous mineral and face identical marginal costs of 20.

International demand for the mineral is given by the inverse demand function:

$$P(Q) = 100 - Q,$$

where total output $Q = Q_1 + Q_2$, the sum of the quantities produced by the two firms.

a. Suppose Firm 1 has the right to choose its annual extraction level first. Firm 2 then chooses its output after observing Firm 1's decision. Determine the Stackelberg equilibrium: quantities, market price, and profits. (2 points)

b. Suppose that initially only Firm 1 operates in the market. Firm 2 is considering entry, but doing so requires paying a fixed cost F . The interaction follows a sequential entry-deterrence game: Firm 1 first chooses its output. Firm 2 then observes this output and decides whether to enter. If Firm 2 enters, the firms play the Stackelberg game with Firm 1 as the leader. If Firm 2 does not enter, Firm 1 remains a monopolist and earns the corresponding profit given its chosen output.

(i) Determine Firm 1's monopoly profit when it does not need to deter entry.

(ii) Determine Firm 2's net profit from entering when Firm 1 does not deter entry.

(iii) For $F = 0$, $F = 200$, and $F > 400$, discuss whether Firm 1 will choose to deter entry. (2 points)

c. Consider that both firms are active in the market and want to form a secret collusive agreement. Under this agreement, they coordinate production as a joint monopolist. Determine the total quantity produced by the cartel. Does it matter how total output is allocated across the two firms? Briefly explain (in words) why such a collusive agreement may not be sustainable. (1 point)

Question 1

a. A strategy is dominant when the best response of a player does not depend on the actions of the other players. When $x < 4$ and $y < 4$, both players have L as a dominant strategy.

b. There are two pure strategy NE: {L,H} and {H,L}. There is also a mixed strategy NE. To find this one, suppose firm 1 mixes over H and L with probability p . In this case, firm 2 is indifferent when:

$$2p + 5(1 - p) = 3p + 4(1 - p) \rightarrow p = \frac{1}{2}$$

Next, suppose firm 2 mixes over H and L with probability λ . In this case, firm 1 is indifferent when:

$$2\lambda + 5(1 - \lambda) = 3\lambda + 4(1 - \lambda) \rightarrow \lambda = \frac{1}{2}$$

Hence, the mixed strategy NE is $\{p = \frac{1}{2}, \lambda = \frac{1}{2}\}$.

c. Firm 1 chooses H, and firm 2 chooses L when firm 1 chooses H, and firm 2 chooses H when firm 1 chooses L. Hence, the subgame perfect NE is {H,{L,H}}.

Question 2

a. Find the follower's (firm 2's) best response function:

$$\begin{aligned} TR_2 &= (100 - Q_1 - Q_2)Q_2 \\ MR_2 &= \frac{\partial TR_2}{\partial Q_2} = 100 - Q_1 - 2Q_2 \\ MR_2 &= MC_2 \\ 100 - Q_1 - 2Q_2 &= 20 \\ Q_2 &= 40 - 0.5Q_1 \end{aligned}$$

Substitute this into the leader's (firm 1's) total revenue and solve for optimal Q_1 :

$$\begin{aligned} TR_1 &= (100 - Q_1 - Q_2)Q_1 \\ TR_1 &= (100 - Q_1 - (40 - 0.5Q_1))Q_1 \\ TR_1 &= (60 - 0.5Q_1)Q_1 \\ MR_1 &= \frac{\partial TR_1}{\partial Q_1} = 60 - Q_1 \\ MR_1 &= MC_1 \\ 60 - Q_1 &= 20 \\ Q_1 &= 40 \end{aligned}$$

Now summarize optimal quantities, price, and profits:

$$\begin{aligned} Q_1 &= 40 \\ Q_2 &= 20 \\ p &= 100 - 40 - 20 = 40 \\ \pi_1 &= 40 * 40 - 20 * 40 = 800 \\ \pi_2 &= 40 * 20 - 20 * 20 = 400 \end{aligned}$$

b. The monopoly profit of firm 1, given that she does not deter entry, can be found by setting MR=MC:

$$\begin{aligned} TR_1 &= (100 - Q_1)Q_1 \\ MR_1 &= \frac{\partial TR_1}{\partial Q_1} = 100 - 2Q_1 \\ MR_1 &= MC_1 \end{aligned}$$

$$\begin{aligned}100 - 2Q_1 &= 20 \\ Q_1 &= 40 \\ p &= 100 - 40 = 60 \\ \pi_1 &= 60 * 40 - 20 * 40 = 1600\end{aligned}$$

The net profit that firm 2 makes when she enters, given that firm 1 does not deter entry, is simply the Stackelberg follower profit minus the fixed costs:

$$\pi_2 = 400 - F$$

First, if $F = 0$, to deter entry, Firm 1 must choose $Q_1 = 80$, such that:

$$\begin{aligned}Q_2 &= 40 - 0.5 * 80 = 0 \\ p &= 100 - 80 - 0 = 20 \\ \pi_2 &= 20 * 0 - 20 * 0 = 0\end{aligned}$$

However, in this case profits of Firm 1 are:

$$\pi_1 = 20 * 80 - 20 * 80 = 0$$

This is lower than Stackelberg leader profits of 800, so Firm 1 does not deter entry.

Second, if $F = 200$, then Firm 1 can choose for instance $Q_1 = 60$ to deter entry, which means that:

$$\begin{aligned}Q_2 &= 40 - 0.5 * 60 = 10 \\ p &= 100 - 60 - 10 = 30 \\ \pi_2 &= 30 * 10 - 20 * 10 = 100\end{aligned}$$

This implies firm 2 will not enter since $\pi_2 = 100 - F < 0$, and since $Q_2 = 0$, we have the following price and profit for firm 1:

$$\begin{aligned}p &= 100 - 60 = 40 \\ \pi_1 &= 40 * 60 - 20 * 60 = 1200\end{aligned}$$

This implies Firm 1 will deter entry by producing more than the monopoly output. It turns out that the minimum (best) amount to deter entry at $F = 200$ would be $Q_1 = 52$.

Third, if $F > 400$, even if Firm 1 does not deter entry and produces the monopoly output of $Q_1 = 40$, Firm 2 will make losses upon entering, since with $Q_2 = 20$ we have that $\pi_2 = 400 - F < 0$. Hence, Firm 1 does not deter entry, and produces $Q_1 = 40$ with $\pi_1 = 1600$.

So Firm 1 only actively deters entry when $F = 200$.

c. As shown under question b, the monopoly output produced by the cartel would be $Q = Q_1 + Q_2 = 40$. In this case, since marginal costs are constant and equal across firms, it does not matter how much each firm produces, as long as they jointly produce 40. They can share the total cartel profit of $\pi = 1600$ to try and give each firm an incentive to cooperate. However, if this game is not repeated an infinite number of times, the cartel is unstable because each firm has an incentive to unilaterally deviate by producing more.