Name: ____________

SID: ____________

EEP100 Final (Dec 15, 2009)

This final is worth 20 percent of your entire grade. The questions are worth 20 points in total. For full credit, show your work. Clear, concise answers are better than disorganized, vague essays. Enjoy!

True/False and Explain [$\frac{1}{2}$ point each]

If you get the T/F wrong, you get *no credit*. If you get the T/F right, then *all* of your credit depends on a good explanation, which need not be long as much as hit the main points.

(1) Some suggest that a high social discount rate (SDR) be used to analyze the cost-benefit of actions to address climate change. This is because we do not know the probabilities of risky outcomes that may result from different sets of actions.

FALSE. First, people suggest using a *low* SDR; second, risk is quantified by probabilities, but *uncertainty* is not. [Extra: It's called Knightian uncertainty by some, but I made the difference between risk and uncertainty clear in class.]

(2) Taxes are less popular than regulations because they are less efficient in changing behavior.

FALSE: Taxes are less popular (with people and politicians) because they are more obvious. Regulations CAN be more efficient in changing behavior, but they are often less efficient (due to problems of definition, enforcement, etc.)

(3) Monopolies (with strong property rights) are good at conserving natural resources.

TRUE. Monopolies have an incentive to *reduce supply* (the rate of resource extraction) because that increases profits. [Extra info: Governments may also be good, but they will not be if they are captured by special interests.]

(4) An Agent with a strong intrinsic motivation to promote the Principal's interest will succeed without need for monitoring.

FALSE. The Agent also has to have skills, i.e., no *Adverse Selection* problem.

(5) In the past, farmers and fishermen in the Netherlands agreed on how to manage land/water.

FALSE. Farmers wanted to *drain wetlands* so they could farm, but this action would reduce the *habitat for fish*, and thus the supply of fish to fishermen.

(6) ♂ + ♀ = ♡

FALSE: Humans are more complicated than mathematics, e.g., they change their behavior when incentives/rules change; see Hazlitt and Schelling.

(7) A Pigouvian tax on A is the best response when A's pollution has an adverse effect on B.

FALSE. That tax requires that a *third* party *intervene* and *calculate* the tax; it's more efficient to assign property rights to A or B and let them negotiate their own *Coasian bargain*.

(8) US sugar production destroyed wetlands and increased the demand for high-fructose-corn-syrup (HFCS); these are market failures.

FALSE. This is an example of *government failure*, i.e., an intervention into the market for sugar (via quotas/tariffs) that's designed to increase the price of sugar. Because prices are high, sugar production occurs in wetlands (potential market failure if we consider the bigger impact on land use decisions, but government failure drives this here) and HFCS is more attractive (cheaper) as a substitute for sugar. Further, these subsidies can be traced to special interests that contribute to politicians who support the policy.

(9) We elect politicians to represent us, but they may not. Voters may have trouble catching them if politicians serve their own interests.

TRUE. Politicians (as our agents) face a *moral hazard* problem (work for us or themselves/special interests). If they defect, an individual may not catch them because an individual's *cost of monitoring* is higher than the benefit, and because it is hard to overcome the *free rider problem* to organize a *collective action* to monitor.

(10) CSR (Corporate Social Responsibility) programs can harm shareholders, especially when CSR officers (bootleggers) protect managers (baptists) pursuing pet projects.

FALSE. The first part is true (managers may pursue side-projects that have nothing to do with profits or, even worse, reduce profits — short- and long-term — because they reflect the manager-cum-agent's "hobbies."), but the second part is false – CSR officers are acting as *baptists*.

(11) Two homo economicus players in a repeated Prisoner's Dilemma will play defect due to bounded rationality.

FALSE. These players can clearly understand the payoffs and consequences of actions (*not bounded* in this situation). Second, they will cooperate in a repeated game because they understand that the best strategy is *tit-for-tat* (I cooperate first. If you defect, I do; if you cooperate, I cooperate).

(12) Gordon's article ("The Economic Theory of a Common-Property Resource: The Fishery") explains why fish farms can succeed.

TRUE. Since fish in farms are *private goods*, they will not be over-exploited like fish in the open sea (a commons) would.

(13) VSL (value of a statistical life) is how much you are WTA (willing to accept) to die.

FALSE. VSL describes the *risk/reward tradeoff* that people make when voluntarily choosing where to work. It uses the differences in the *probability* of death – not certain death – and wages to find the value of a "*statistical* life."

(14) A risk-averse person will take a risky gamble – even when expected earnings are below risk-free earnings – in exchange for a suitable "option" payment.

TRUE. Flip this on its head: A risk-averse person will make an option payment to *avoid risk* (the difference between expected and certain earnings), so that person will accept a payment to *take the risk*. For example, a payment of $1.00 to take a chance on a 50/50 coin toss with $3/$1 earnings compared to the risk-free payment of $2.10.

(15) Competition for grades is like competition for jobs, peer-grading in class is like peer-review in a company, and a professor's decision on grades is like a boss's decision on salaries.

TRUE. Unless grades are on an absolute scale (and they are NOT if there is competition for them), they are competitive. For example, a "curve" is based on the average score; if that score is lower, you have more points assigned to your grade. Thus, you want your peers to do worse, to lower the average. Peer-grading is the same, with a complication. On the one hand, you want to defame co-workers, on the other hand(s), such defamation can backfire if you are caught (this is why we compared three peer-grades for each briefing) and defamation can weaken the team, leading to a total collapse of cooperation/the company. The professor/boss is *supposed* to follow rules in assigning grades, but bribes/bias can influence them. The counter-force to this is short-term (the boss/professor gets caught) and long-term (the business/society is worse off if "unfair" grades are given). Remember the cookies!

(16) According to Schelling, we slow down to look at a traffic accident for ten seconds because that marginal benefit is worth the ten minute cost we've just paid.

FALSE. First, that ten minutes is a *sunk cost*. Second, the real decision (at the margin) is whether the benefit from slowing/looking is worth the *cost of ten extra seconds* it takes us to slow down and look. Since it often is, we add to the misery/wait time of the people behind us. [Extra: one solution for this is to put a (fabric) wall around accidents until they are cleaned up; nothing to see, so people will drive by faster...]

Longer Questions [2 points each]

Show your work! (Use the back of the page but put your answers in the spaces provided.)
Note that *pure strategy Nash equilibrium/ia* occur when a player has no incentive to change his move (an action, not a combination of actions), given the move of the other player.

(1) These are simultaneous move, one-shot games.
  (a) Find the pure and mixed strategy Nash equilibrium/ia in this game.

		Player 2	
		A	B
Player 1	C	3,4	5,5
	D	9,2	0,1

Answer:

		Player 2	
		A	B
Player 1	C	3,4	$\underline{5},\underline{5}$
	D	$\underline{9},\underline{2}$	0,1

Pure strategy solutions occur where the best responses overlap, i.e. both payoffs in the box are underlined. There are two: (B,C) and (A,D).

Mixed strategy. Let p be the probability that player 1 plays C and (1-p) be the probability that player 1 plays D. Calculate p by setting the expected utility of player 2 for playing A equal to that for playing B.

$$EU_A = EU_B$$

$$4p + 2(1-p) = 5p + 1(1-p)$$

$$2p + 2 = 4p + 1$$

$$1 = 2p$$

$$p = \frac{1}{2}$$

Let q be the probability that player 2 plays A and (1-q) be the probability that player 2 plays B. Calculate q by setting the expected utility of player 1 for playing C equal to that for playing D.

$$EU_C = EU_D$$

$$3q + 5(1-q) = 9q + 0(1-q)$$

$$-2q + 5 = 9q$$

$$5 = 11q$$

$$q = \frac{5}{11}$$

There is one mixed strategy equilibrium where Player 1 player C and D with probability of $\frac{1}{2}$ and Player 2 plays A and B with probability $\frac{5}{11}$ and $\frac{6}{11}$, respectively.

(b) Find the pure strategy Nash equilibrium/ia in this game.

Player 2

		A	B
Player 1	C	0,2	3,1
	D	5,4	-1,2

Answer:

Player 2

		A	B
Player 1	C	0,$\underline{2}$	$\underline{3}$,1
	D	$\underline{5}$,$\underline{4}$	-1,2

Pure strategy solutions occur where the best responses overlap, i.e. both payoffs in the box are underlined. There is one: (A,D).

(c) Find the pure strategy Nash equilibrium/ia in this game.

Player 2

		A	B
Player 1	C	-1,2	3,1
	D	4,4	5,4

Answer:

Player 2

		A	B
Player 1	C	-1,$\underline{2}$	3,1
	D	$\underline{4}$,$\underline{4}$	$\underline{5}$,$\underline{4}$

Pure strategy solutions occur where the best responses overlap, i.e. both payoffs in the box are underlined. There are two: (A,D) and (B,D).

(d) Find the pure and mixed strategy Nash equilibrium/ia in this game.

Player 2

		A	B
Player 1	C	0,-2	4,0
	D	-1,6	6,-3

Answer:

Player 2

		A	B
Player 1	C	$\underline{0}$,-2	4,$\underline{0}$
	D	-1,$\underline{6}$	$\underline{6}$,-3

There are no pure strategy equilibria. Mixed strategy. Let p be the probability that player 1 plays C and (1-p) be the probability that player 1 plays D. Calculate p by setting the expected utility of player 2 for playing A equal to that for playing B.

$$\begin{aligned} EU_A &= EU_B \\ -2p + 6(1-p) &= 0p - 3(1-p) \\ -8p + 6 &= -3 + 3p \\ 9 &= 11p \\ p &= \frac{9}{11} \end{aligned}$$

Let q be the probability that player 2 plays A and (1-q) be the probability that player 2 plays B. Calculate q by setting the expected utility of player 1 for playing C equal to that for playing D.

$$\begin{aligned} EU_C &= EU_D \\ 0q + 4(1-q) &= -1q + 6(1-q) \\ -4q + 4 &= -7q + 6 \\ 2 &= 3q \\ q &= \frac{2}{3} \end{aligned}$$

There is one mixed strategy equilibrium where Player 1 player C and D with probability of $\frac{9}{11}$ and $\frac{2}{11}$, respectively and Player 2 plays A and B with probability $\frac{2}{3}$ and $\frac{1}{3}$, respectively.

(2) Consider the following simultaneous move, one-shot game. **(Do not look for mixed strategies.)**

Player 2

		A	B	C	D	E
	F	-1,2	3,0	2,5	0,-2	4,7
	G	4,3	1,8	0,0	6,8	2,-2
Player 1	H	0,2	1,-1	5,4	6,0	-4,5
	I	4,5	8,7	-1,-3	5,1	3,6
	J	6,2	10,3	3,8	-9,-6	-3,-5

(a) Find all pure strategy Nash equilibrium/ia.
Answer:

Player 2

		A	B	C	D	E
	F	-1,2	3,0	2,5	0,-2	$\underline{4}$,$\underline{7}$
	G	4,3	1,$\underline{8}$	0,0	$\underline{6}$,$\underline{8}$	2,-2
Player 1	H	0,2	1,-1	$\underline{5}$,4	$\underline{6}$,0	-4,$\underline{5}$
	I	4,5	8,$\underline{7}$	-1,-3	5,1	3,6
	J	$\underline{6}$,2	$\underline{10}$,3	3,$\underline{8}$	-9,-6	-3,-5

There are two pure strategy equilibria at (F,E) and (G,D).

(b) Are there any moves that Player 1 would never choose? Are there any moves that Player 2 would never choose? Identify these moves if they exist. Explain your answer.
Answer: Player 1 would never choose move I because for whatever move Player 2 makes, I is *never* the optimal choice. That is, looking across row I, there are no underlines for player 1's payoffs. Similarly, Player 2 would never choose move A.

(c) Suppose this is a sequential move game (i.e., with the branch structure) where Player 1 moves first and then Player 2 moves after observing Player 1. Taking away irrelevant moves (if any) that you found in (b), how many decision nodes would Player 1 have? How many would Player 2 have? How many payoff pairs will there be?
Answer: Player 1 only has one decision node, since he chooses first. Off of this node, he will have four branches (eliminating choice I from above). Player 2 has four decision nodes, one at the end of each of Player 1's branches. Each of player 2's decision nodes also has four branches (eliminating choice A from above). Thus, there are 4X4 payoff pairs, giving a total of 16.

(3) Consider the following game with complete information. Suppose that Coke is debating whether or not to enter a new market where the market is dominated by its rival, Pepsi. Suppose that the game proceeds as follows: First, Coke chooses to enter the new market or stay out; Second, if Coke chooses to enter, then Pepsi reacts by either playing "tough" (e.g. mounts a big advertising campaign) or "accommodate" (e.g. does not mount such a tough counterattack). Simultaneously, Coke makes its

second move (if it enters), by playing either "counter ad-tack" (get it? hahaha) or "nothing" *without* observing Pepsi's reaction. Therefore we can draw the game tree below ("Figure. Coke vs Pepsi"), where E means "enter", O means "stay out", T means "tough", A means "accommodate", C means "counter ad-tack" and N means "nothing". Note that the first entry in each pair of payoffs is Coke's payoff, and the second entry is Pepsi's payoff.

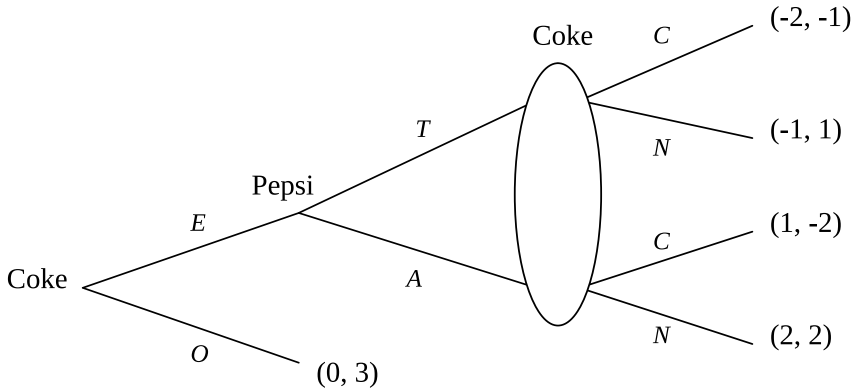

Figure. Coke vs Pepsi

Suppose that both Coke and Pepsi want to maximize their own payoffs. Find one pure strategy Nash equilibrium in this game.

Answer:

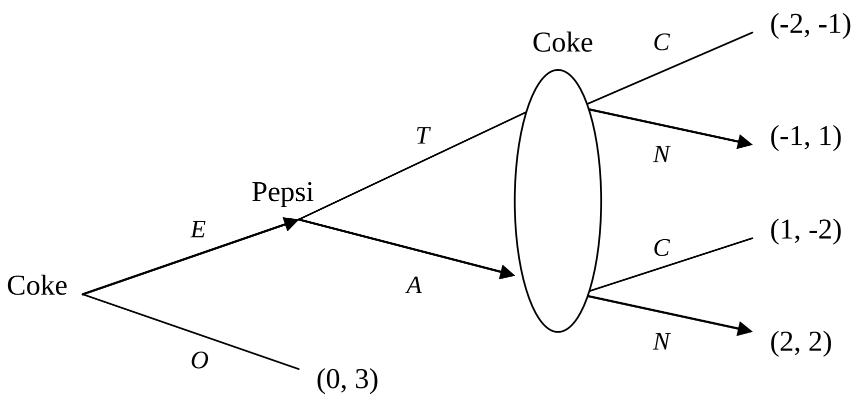

Figure. Coke vs Pepsi

Backward induction: in the last step, no matter Pepsi chooses "T" or "A", Coke can always get greater payoffs by choosing "N", therefore in Nash equilibrium Coke will choose "N" in the last step. Then knowing that Coke will always choose "N" in the last step, Pepsi will choose "A" because the payoff that Pepsi gets from choosing "A" (2) is greater than choosing "T" (1). Finally, knowing that Pepsi will always choose "A", Coke will choose "E" in the first step because the payoff that Coke gets from choosing "E" (2) is greater than choosing "O" (0).

Therefore, the pure strategy Nash equilibrium is (E, N; A).

(4) Consider the following sequential move game with complete information in the figure below ("Figure. Nature & two players"). The game proceeds as follows: First, Nature moves UP with a probability of 0.75 and $DOWN$ with a probability of 0.25; Second, Player 1 moves U^1 or D^1; Finally, Player 2 moves U^2 or D^2 (not all branches are marked on the figure). Assume that neither player knows Nature's move, but Player 2 observes Player 1's move. Suppose that both players are risk-neutral, i.e. they want to maximize their own expected payoffs. In the figure, N means "Nature", $P1$ means "Player 1", and $P2$ means "Player 2".

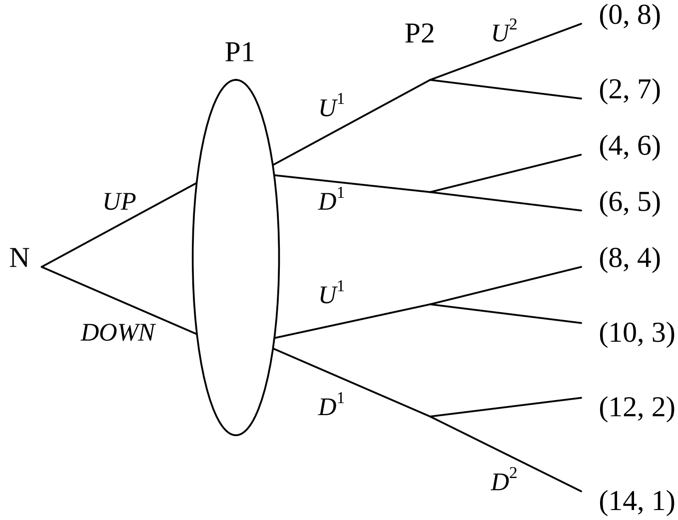

Figure. Nature & two players

(a) Use circles to join the decision nodes that Player 2 cannot tell apart in the figure.

Answer: Decision nodes 1 and 3 are one pair, and decision nodes 2 and 4 are the other pair. In other words, Player 2 cannot tell apart decision nodes 1 and 3, and cannot tell apart decision nodes 2 and 4.

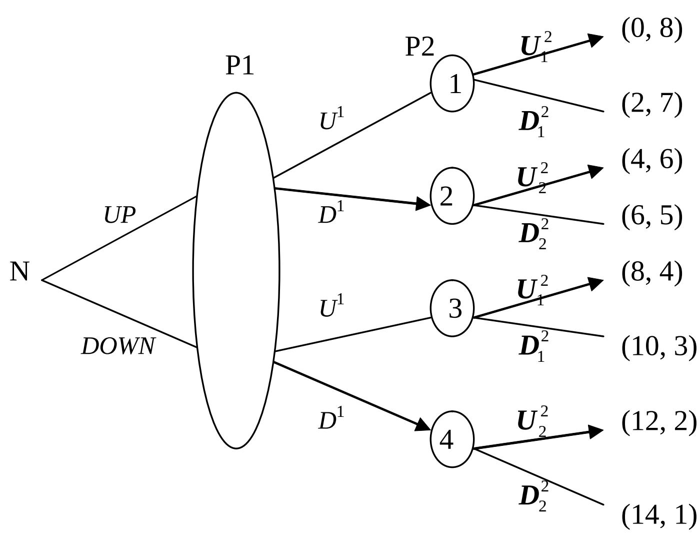

Figure. Nature & two players

(b) Use backward induction to find the pure strategy Nash equilibrium in this game.

Answer: Given Player 1 chooses U^1: Player 2 has two moves U_1^2 and U_2^2.
Player 2's expected payoff from choosing U_1^2 is: $E\pi_2(U_1^2) = 0.75 * 8 + 0.25 * 4 = 7$
Player 2's expected payoff from choosing D_1^2 is: $E\pi_2(D_1^2) = 0.75 * 7 + 0.25 * 3 = 6$
Since $E\pi_2(U_1^2) > E\pi_2(D_1^2)$, then if Player 1 chooses U^1, player 2 will choose U_1^2.
Given Player 1 chooses D^1: Player 2 has two moves U_2^2 and D_2^2.
Player 2's expected payoff from choosing U_2^2 is: $E\pi_2(U_2^2) = 0.75 * 6 + 0.25 * 2 = 5$
Player 2's expected payoff from choosing D_2^2 is: $E\pi_2(D_2^2) = 0.75 * 5 + 0.25 * 1 = 4$
Since $E\pi_2(U_2^2) > E\pi_2(D_2^2)$, therefore, if Player 1 chooses D^1, then player 2 will choose U_2^2.
Knowing Player 2's strategy, Player 1 is choosing between his two moves U^1 and D^1.
Player 1's expected payoff from choosing U^1 is: $E\pi_1(U^1) = 0.75 * 0 + 0.25 * 8 = 2$
Player 1's expected payoff from choosing D^1 is: $E\pi_1(D^1) = 0.75 * 4 + 0.25 * 12 = 6$
Since $E\pi_1(U^1) > E\pi_1(D^1)$, then Player 1 will choose D^1 in equilibrium.
Therefore, one pure strategy Nash equilibrium is: (Player 1 chooses D^1; Player 2 chooses U^2 no matter what move Player 1 takes).

(5) Consider an isolated market (no other entry) with complete information in which three firms are producing identical milk. Suppose that Firm 1 is the leader in the market in the sense that Firm 1 chooses its own production quantity q_1 first, and Firm 2 and Firm 3 are both followers in the sense that they simultaneously choose their production quantities q_2 and q_3 after observing Firm 1's choice. Assume that Firm 1 has a marginal cost of \$1 per gallon of milk, and both Firm 2 and Firm 3 have a marginal cost of \$2 per gallon of milk, and also assume that there are no fixed costs. The market demand Q is a linear function of the milk price P: $Q = 11 - P$.

(a) Find the reaction functions for Firm 2 and Firm 3 (hint: as a function of q_1.)
Answer: Firm 2 and Firm 3 play a Cournot game first, and then play a Stackelberg game with Firm 1 (the leader) as followers.
The inverse demand function is: $P = 11 - Q = 11 - q_1 - q_2 - q_3$.
In the Cournot game between Firm 2 and Firm 3, the profit-max problem for Firm 2 is (taking q_1 and q_3 as given):
$\underset{q_2}{max}\ \pi_2 = P * q_2 - MC_2 * q_2 = (P - MC_2) * q_2 = (11 - q_1 - q_2 - q_3 - 2) * q_2 = (9 - q_1 - q_2 - q_3) * q_2$
$\Longrightarrow F.O.C.: \quad \frac{\partial \pi_2}{\partial q_2} = -q_2 + (9 - q_1 - q_2 - q_3) = 0$
$\Longrightarrow \quad q_2 = \frac{1}{2}(9 - q_1 - q_3) \quad \cdots\cdots\cdots\cdots \quad (1)$
Analogously, the profit-max problem for Firm 3 is (taking q_1 and q_2 as given):
$\underset{q_3}{max}\ \pi_3 = P * q_3 - MC_3 * q_3 = (P - MC_3) * q_3 = (11 - q_1 - q_2 - q_3 - 2) * q_3 = (9 - q_1 - q_2 - q_3) * q_3$
$\Longrightarrow F.O.C.: \quad \frac{\partial \pi_3}{\partial q_3} = -q_3 + (9 - q_1 - q_2 - q_3) = 0$
$\Longrightarrow \quad q_3 = \frac{1}{2}(9 - q_1 - q_2) \quad \cdots\cdots\cdots\cdots \quad (2)$
Then substitute equation (2) into equation (1), we can get:

$q_2 = \frac{1}{2}(9 - q_1 - q_3) = \frac{1}{2}\left[9 - q_1 - \frac{1}{2}(9 - q_1 - q_2)\right] = \frac{1}{4}(9 - q_1) + \frac{q_2}{4}$
$\Longrightarrow \quad q_2^\star = \frac{1}{3}(9 - q_1) = 3 - \frac{q_1}{3}$
$\Longrightarrow \quad q_3^\star = \frac{1}{2}(9 - q_1 - q_2^\star) = \frac{1}{2}(9 - q_1 - 3 + \frac{q_1}{3}) = 3 - \frac{q_1}{3}$
Therefore the reaction functions for Firm 2 and Firm 3 are:
$$\begin{cases} q_2^\star = 3 - \frac{q_1}{3} \\ q_3^\star = 3 - \frac{q_1}{3} \end{cases}$$

(b) Find the equilibrium production quantity for each of the three firms.

Answer: Knowing the reaction functions of Firm 2 and Firm 3, Firm 1 (the leader) has the following profit-max problem in the Stackelberg game:
$\max_{q_1} \pi_1 = P * q_1 - MC_1 * q_1 = (P - MC_1) * q_1 = (11 - q_1 - q_2^\star - q_3^\star - 1) * q_1 = \left[10 - q_1 - 2 * (3 - \frac{q_1}{3})\right] * q_1 = (4 - \frac{q_1}{3}) * q_1$
$\Longrightarrow F.O.C.: \qquad \frac{\partial \pi_1}{\partial q_1} = -\frac{q_1}{3} + (4 - \frac{q_1}{3}) = 0$
$\Longrightarrow \quad q_1^\star = 6$
Substituting $q_1^\star$ into the reaction functions of Firm 2 and Firm 3, we can get the equilibrium quantities of Firm 2 and Firm 3:
$q_2^\star = q_3^\star = 3 - \frac{q_1^\star}{3} = 3 - 2 = 1$
Therefore the equilibrium production quantity for each of the three firms is:
$$\begin{cases} q_1^\star = 6 \\ q_2^\star = 1 \\ q_3^\star = 1 \end{cases}$$

(c) Find market price ($P^\star$) and quantity ($Q^\star$) in equilibrium.

Answer: The market quantity is: $Q^\star = q_1^\star + q_2^\star + q_3^\star = 6 + 1 + 1 = 8$
The market price is: $P^\star = 11 - Q^\star = 11 - 8 = 3$

(d) Compute each firm's equilibrium profit.

Answer: The equilibrium profit of Firm 1 is:
$\pi_1 = (P^\star - MC_1) * q_1^\star = (3 - 1) * 6 = 12$
The equilibrium profit of Firm 2 is:
$\pi_2 = (P^\star - MC_2) * q_2^\star = (3 - 2) * 1 = 1$
The equilibrium profit of Firm 3 is:
$\pi_3 = (P^\star - MC_3) * q_3^\star = (3 - 2) * 1 = 1$

(6) Ella is a fan of extreme sports and gets utility from skiing in dangerous areas. Suppose her utility from skiing is given by $4x^{\frac{1}{2}}$, where x is the number of years she chooses to ski. Suppose also that there is a utility cost of skiing associated with the injuries she faces given by $-x$.

(a) Write down Ella's total utility from skiing (taking both her benefits and costs into account). Determine her optimal level of skiing (assume she maximizes her utility in all parts of this question).

Answer: $U = 4x^{\frac{1}{2}} - x$
Taking the derivative and setting it equal to zero, we have
$\frac{dU}{dx} = 2x^{-\frac{1}{2}} - 1 = 0$

$2x^{-\frac{1}{2}} = 1$
$x^{-\frac{1}{2}} = \frac{1}{2}$
$\frac{1}{x^{\frac{1}{2}}} = \frac{1}{2}$
$x^{\frac{1}{2}} = 2$
$x = 4$

(b) Suppose now that Ella has health insurance (for no cost) and she only faces half of the cost associated with skiing while her insurance company pays the rest. Write down Ella's new total utility and determine her optimal level of skiing.

Answer: $U = 4x^{\frac{1}{2}} - \frac{1}{2}x$
Taking the derivative and setting it equal to zero, we have
$\frac{dU}{dx} = 2x^{-\frac{1}{2}} - \frac{1}{2} = 0$
$x^{-\frac{1}{2}} = \frac{1}{4}$
$\frac{1}{x^{\frac{1}{2}}} = \frac{1}{4}$
$x^{\frac{1}{2}} = 4$
$x = 16$

(c) Compare the results from parts (a) and (b). Is this an example of moral hazard, adverse selection, or neither? Explain.

Answer: We see from part (a) and (b) that Ella skis significantly more once she has insurance. This is an example of moral hazard where the principal is the insurance company and she is the agent. Since she no longer bears the entire cost of her actions, she takes riskier actions than optimal.

(d) Suppose now that Ella does not have "ski career" insurance and is deciding if she wants to buy it one thousand dollars. Explain how Ella decides if she is going to buy the insurance (or not) and how much she skis, if she does or does not decide to buy the insurance.

Answer: She compares the utility from 16 years of skiing less the disutility of spending $1,000 to the utility from 4 years of skiing. Discount rates matter. If she buys/does not buy the insurance, she skis the same amount of time, since the cost of insurance has no impact on the margin. (It's a sunk cost.)