# Last Time

- Balance theorem – statement and proof.
- Weak structural balance.
- Weak balance theorem – statement (read proof on textbook).
- Game theory introduction.
- Presentation vs. exam example.

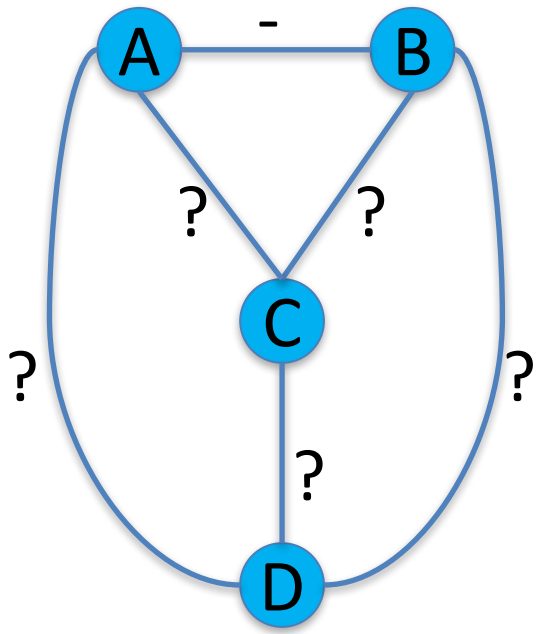
# Warm Up

Label edges with a question mark with a ‘+’ or ‘-’ such that the network is:

a. Balanced

b. Weakly balanced but not balanced

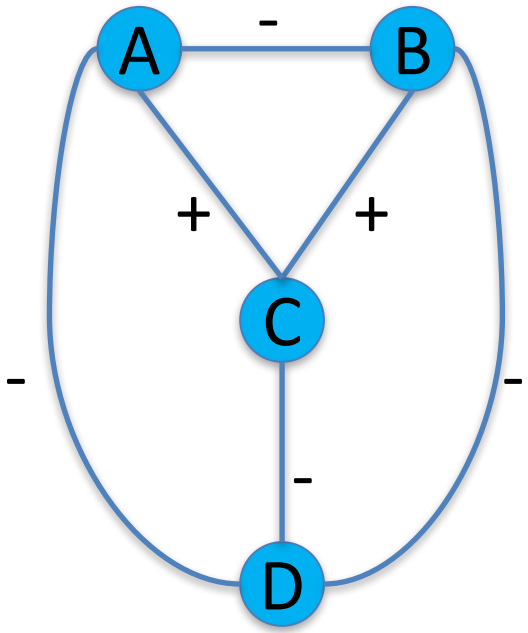
c. Not balanced or weakly balanced



# Warm Up

1. This network is:

   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



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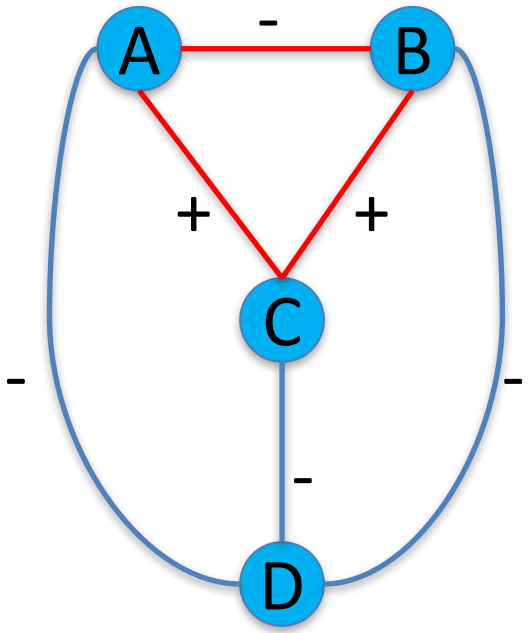
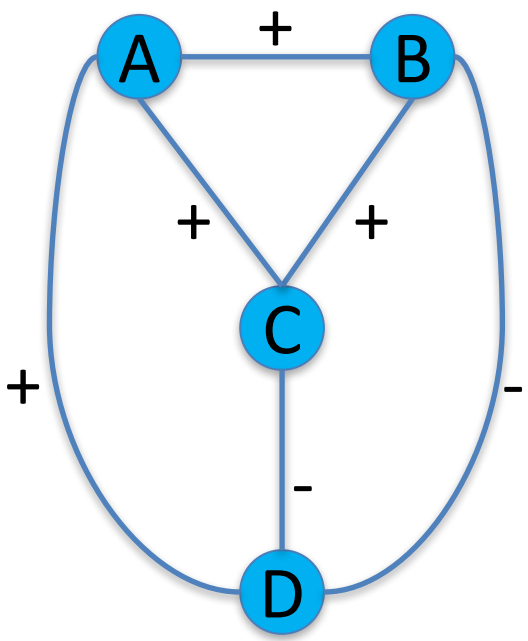


# Warm Up

2. This network is:

   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



# Warm Up

2. This network is:

   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
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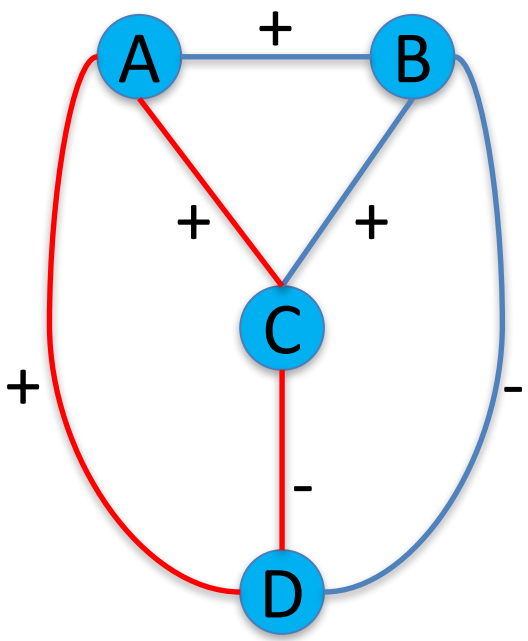
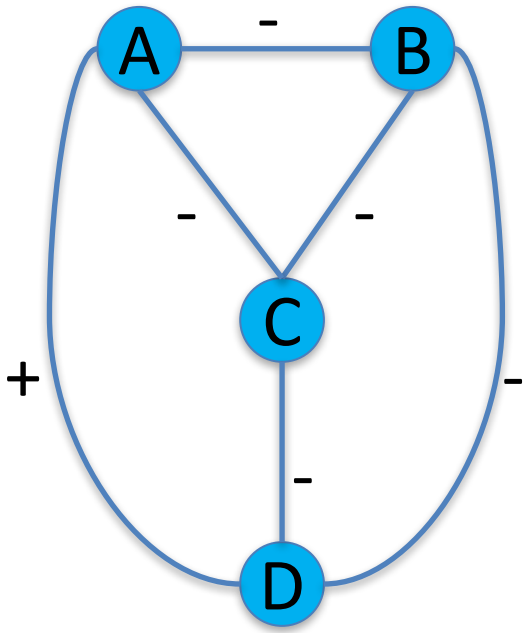
   E. Node of the above



# Warm Up

3. This network is:

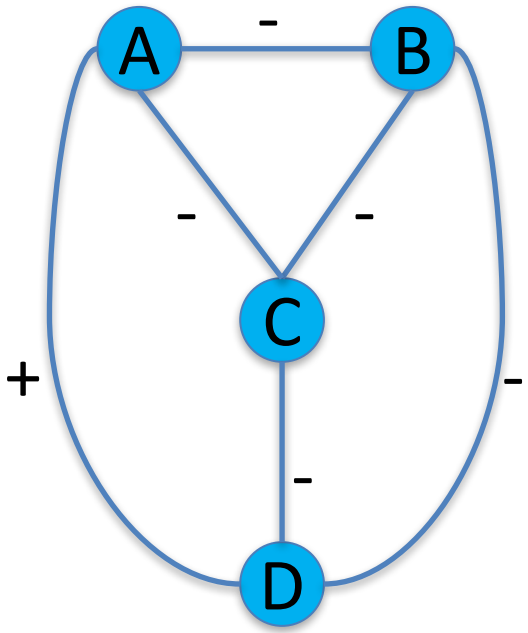
   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



# Warm Up

3. This network is:

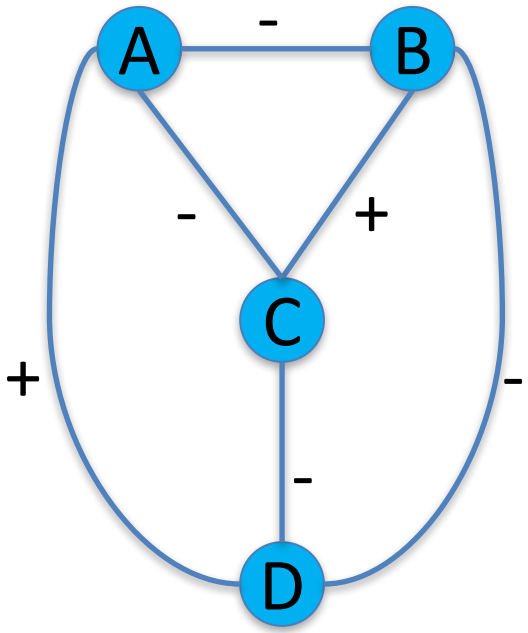
   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



# Warm Up

4. This network is:

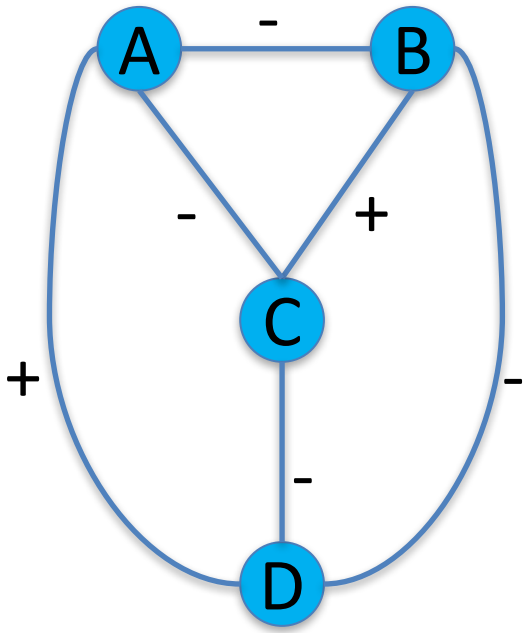
   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



# Warm Up

4. This network is:

   A. Balanced
   B. Weakly balanced but not balanced
   C. Not balanced or weakly balanced
   D. Incomplete
   E. Node of the above



# Presentation vs. Exam

- Presentation with a partner and exam tomorrow.

# Presentation vs. Exam

- Presentation with a partner and exam tomorrow.
- You and your partner only have time to prepare for one.

# Presentation vs. Exam

- Presentation with a partner and exam tomorrow.
- You and your partner only have time to prepare for one.
- Exam:
  - If you study for the exam you will get a 92
  - If you don’t study you will get an 80.

# Presentation vs. Exam

- Presentation with a partner and exam tomorrow.
- You and your partner only have time to prepare for one.
- Exam:
  - If you study for the exam you will get a 92
  - If you don’t study you will get an 80.
- Presentation:
  - If both you and your partner prepare you get 100
  - If only one of you prepares you get 92
  - If neither of you prepare you get 84

# Presentation vs. Exam

- Presentation with a partner and exam tomorrow.
- You and your partner only have time to prepare for one.
- Exam:
  - If you study for the exam you will get a 92
  - If you don’t study you will get an 80.
- Presentation:
  - If both you and your partner prepare you get 100
  - If only one of you prepares you get 92
  - If neither of you prepare you get 84
- You cannot coordinate with your partner

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | | | |
| Exam | Presentation | | | |
| Presentation | Exam | | | |
| Presentation | Presentation | | | |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | |
| Exam | Presentation | | | |
| Presentation | Exam | | | |
| Presentation | Presentation | | | |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | 88 |
| Exam | Presentation | | | |
| Presentation | Exam | | | |
| Presentation | Presentation | | | |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | 88 |
| Exam | Presentation | 92 | 92 | 92 |
| Presentation | Exam | | | |
| Presentation | Presentation | | | |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | 88 |
| Exam | Presentation | 92 | 92 | 92 |
| Presentation | Exam | 80 | 92 | 86 |
| Presentation | Presentation | | | |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | 88 |
| Exam | Presentation | 92 | 92 | 92 |
| Presentation | Exam | 80 | 92 | 86 |
| Presentation | Presentation | 80 | 100 | 90 |

# Presentation vs. Exam

| You study for | Your Partner studies for | Your exam grade | Your presentation grade | Your average |
|---|---|---|---|---|
| Exam | Exam | 92 | 84 | 88 |
| Exam | Presentation | 92 | 92 | 92 |
| Presentation | Exam | 80 | 92 | 86 |
| Presentation | Presentation | 80 | 100 | 90 |

# Presentation vs. Exam

**The game:**

**Your Partner**

| **You** | | **Presentation** | **Exam** |
|---|---|---|---|
| | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# Presentation vs. Exam

**The game**:

- **Players**: You and Your Partner

| | | Your Partner: Presentation | Your Partner: Exam |
|---|---|---|---|
| You | Presentation | 90, 90 | 86, 92 |
| | Exam | 92, 86 | 88, 88 |

# Presentation vs. Exam

**The game**:

- **Players**: You and Your Partner
- **Strategies**: Prepare for “Presentation” and “Exam”

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# Presentation vs. Exam

**The game**:

- **Players**: You and Your Partner
- **Strategies**: Prepare for “Presentation” and “Exam”
- **Payoffs**: The average grade of presentation and exam

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# Presentation vs. Exam

**The game**:

- **Players**: You and Your Partner
- **Strategies**: Prepare for “Presentation” and “Exam”
- **Payoffs**: The average grade of presentation and exam

Your Partner’s payoff

**Your Partner**

| | **Presentation** | **Exam** |
|---|---|---|
| **Presentation** | 90, 90 | 86, 92 |
| **Exam** | 92, 86 | 88, 88 |

**You**

Your payoff

# Presentation vs. Exam

**The game**:

- **Players**: You and Your Partner
- **Strategies**: Prepare for “Presentation” and “Exam”
- **Payoffs**: The average grade of presentation and exam
- **Payoff Matrix**: Summarizes the game.

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# Game Assumptions

- Players only care about the payoffs in the game.

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# Game Assumptions

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  - Players want to get the highest payoff possible

# Game Assumptions

- Players only care about the payoffs in the game.

- Each player has complete information about the game:
  - Strategies available to all players.
  - Payoffs for each choice of strategies for all players.

- All players are *rational*:
  - Players want to get the highest payoff possible
  - Players will choose strategies that optimize their payoff, if they can.

# How would you play this game?

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam →

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam →

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam → you should study for the exam to get 88 instead of 86.

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam → you should study for the exam to get 88 instead of 86.
- If your partner prepares for the presentation →

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam → you should study for the exam to get 88 instead of 86.
- If your partner prepares for the presentation → you should study for the exam to get 92 instead of 90.

**Your Partner**

| **You** | | **Presentation** | **Exam** |
|---|---|---|---|
| | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# How would you play this game?

- If your partners studies for the exam → you should study for the exam to get 88 instead of 86.
- If your partner prepares for the presentation → you should study for the exam to get 92 instead of 90.

**Regardless of your friend's strategy, you should study for exam.**

| | | **Your Partner** | |
|---|---|---|---|
| | | **Presentation** | **Exam** |
| **You** | **Presentation** | 90, 90 | 86, 92 |
| | **Exam** | 92, 86 | 88, 88 |

# Outcome Prediction

A ***Strictly dominant strategy*** for a player is a strategy that is strictly better than all other options regardless of what the other player does.

| | | **Your Partner** | |
|---|---|---|---|
| | | **P** | **E** |
| **You** | **P** | 90, 90 | 86, 92 |
| | **E** | 92, 86 | 88, 88 |

# Outcome Prediction

A ***Strictly dominant strategy*** for a player is a strategy that is strictly better than all other options regardless of what the other player does.

"Exam" is a strictly dominant strategy for both players. We expect both players to choose "Exam" getting 88.

| | | **Your Partner** | |
|---|---|---|---|
| | | **P** | **E** |
| **You** | **P** | 90, 90 | 86, 92 |
| | **E** | 92, 86 | 88, 88 |

# Outcome Prediction

A ***Strictly dominant strategy*** for a player is a strategy that is strictly better than all other options regardless of what the other player does.

"Exam" is a strictly dominant strategy for both players. We expect both players to choose "Exam" getting 88.

If you both players chose "Presentation", they would both get a higher payoff of 90, but this outcome is not achievable without coordination.

| | | **Your Partner** | |
|---|---|---|---|
| | | **P** | **E** |
| **You** | **P** | 90, 90 | 86, 92 |
| | **E** | 92, 86 | 88, 88 |

# Prisoners Dilemma

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They are both told the following:

# Prisoners Dilemma

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- If you both confess, you will both get a 4 year sentence

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- If you both confess, you will both get a 4 year sentence
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| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | | |
| | **NC** | | |

# Prisoners Dilemma

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| | **NC** | | |

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| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | | 0, -10 |
| | **NC** | -10, 0 | |

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| | | **Suspect 2** | |
|---|---|---|---|
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| **Suspect 1** | **C** | | 0, -10 |
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- If neither one of you confesses, you will both get a 1 year sentence.

| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | |

# Prisoners Dilemma

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- If you confess and your partner doesn't, you will be released and your partner will get a 10 year sentence.
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|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
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# Prisoners Dilemma

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- If you confess and your partner doesn't, you will be released and your partner will get a 10 year sentence.
- If you both confess, you will both get a 4 year sentence
- **If neither one of you confesses, you will both get a 1 year sentence.**

| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

What should be prisoner's 1 strategy?

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

What should be prisoner's 1 strategy?

- If suspect 2 confesses, suspect 1 should confess to get -4 instead of -10.

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

What should be prisoner's 1 strategy?

- If suspect 2 confesses, suspect 1 should confess to get -4 instead of -10.
- If suspect 2 does not confess, suspect 1 should confess to get 0 instead of -1.

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

What should be prisoner's 1 strategy?

- If suspect 2 confesses, suspect 1 should confess to get -4 instead of -10.
- If suspect 2 does not confess, suspect 1 should confess to get 0 instead of -1.

| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

No matter what suspect 2 does, suspect 1 should confess. So *Confess* is a *strictly dominant strategy* for suspect 1.

# Prisoners Dilemma

What should be prisoner's 1 strategy?

- If suspect 2 confesses, suspect 1 should confess to get -4 instead of -10.
- If suspect 2 does not confess, suspect 1 should confess to get 0 instead of -1.

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

No matter what suspect 2 does, suspect 1 should confess. So *Confess* is a *strictly dominant strategy* for suspect 1.
By symmetry, confess is also *a strictly dominant strategy* for suspect 2.

# Prisoners Dilemma

Players will not achieve the better outcome of -1,-1.

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

Players will not achieve the better outcome of -1,-1.

Cooperation vs. Self interest.

| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

Players will not achieve the better outcome of -1,-1.

Cooperation vs. Self interest.

Prisoners dilemma models other situations such as:

- Performance-enhancing drugs in professional sports

| | | **Suspect 2** | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Prisoners Dilemma

Players will not achieve the better outcome of -1,-1.

Cooperation vs. Self interest.

Prisoners dilemma models other situations such as:

- Performance-enhancing drugs in professional sports
- Arms races between opposing nations.

| | | Suspect 2 | |
|---|---|---|---|
| | | **C** | **NC** |
| **Suspect 1** | **C** | -4, -4 | 0, -10 |
| | **NC** | -10, 0 | -1,-1 |

# Some Notation

If *S* is a strategy chosen by player *1*, and *T* is a strategy chosen by player *2*, we say $P_i(S,T)$ is the payoff to player *i:*

| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Some Notation

If *S* is a strategy chosen by player *1*, and *T* is a strategy chosen by player *2*, we say $P_i(S,T)$ is the payoff to player *i:*

Find:

$P_1(S1,S1)$ =
$P_1(S1,S2)$ =
$P_2(S2,S2)$ =
$P_2(S2,S1)$ =
$P_1(S2,S1)$ =

| | | Player 2 | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Some Notation

If *S* is a strategy chosen by player *1*, and *T* is a strategy chosen by player *2*, we say $P_i(S,T)$ is the payoff to player *i:*

Find:

$P_1(S1,S1) = -4$
$P_1(S1,S2) =$
$P_2(S2,S2) =$
$P_2(S2,S1) =$
$P_1(S2,S1) =$

| | | Player 2 | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Some Notation

If *S* is a strategy chosen by player *1*, and *T* is a strategy chosen by player *2*, we say $P_i(S,T)$ is the payoff to player *i:*

Find:

$P_1(S1,S1) = -4$
$P_1(S1,S2) = 0$
$P_2(S2,S2) =$
$P_2(S2,S1) =$
$P_1(S2,S1) =$

| | | Player 2 | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Some Notation

If *S* is a strategy chosen by player *1*, and *T* is a strategy chosen by player *2*, we say $P_i(S,T)$ is the payoff to player *i:*

Find:

$P_1(S1,S1) = -4$
$P_1(S1,S2) = 0$
$P_2(S2,S2) = -1$
$P_2(S2,S1) =$
$P_1(S2,S1) =$

| | | Player 2 | |
|---|---|---|---|
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$P_2(S2,S1) = 0$
$P_1(S2,S1) = -10$

| | | Player 2 | |
|---|---|---|---|
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# Best Responses and Dominant Strategies

**A best response** is the best choice for a player given the strategy chosen by her opponent.

| | | **Player 2** | |
|---|---|---|---|
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# Best Responses and Dominant Strategies

**A best response** is the best choice for a player given the strategy chosen by her opponent.

Strategy S for Player 1 is a **best response** to strategy T of Player 2 if:

$P_1(S,T) \geq P_1(S',T)$ for all other strategies S'

| | | **Player 2** | |
|---|---|---|---|
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|---|---|---|---|
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What's the best response by player 2 to strategy S1 of player 1?

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|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
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$P_1(S,T) \geq P_1(S',T)$ for all other strategies S'

What's the best response by player 2 to strategy S1 of player 1?
$P_2(S1,S1) = -4$ and $P_2(S1,S2) = -10$, so S1 is the best response by player 2.

# Best Responses and Dominant Strategies

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Strategy S for Player 1 is a **best response** to strategy T of Player 2 if:

| | | Player 2 | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 4, -4 |
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$P_1(S,T) \geq P_1(S',T)$ for all other strategies S'

What's the best response by player 2 to strategy S1 of player 1?
$P_2(S1,S1) = -4$ and $P_2(S1,S2) = -4$, so S1 and S2 are both best responses by player 2.

# Best Responses and Dominant Strategies

There could be multiple best responses to a strategy if more than one strategy has the same payoff.

When a single best response exists, we call it a **strict best response.**

| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Best Responses and Dominant Strategies

There could be multiple best responses to a strategy if more than one strategy has the same payoff.

When a single best response exists, we call it a **strict best response.**

Strategy S for Player 1 is a **strict best response** to strategy T for Player 2 if:

$P_1(S,T) > P_1(S',T)$ for all other strategies S'

| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Best Responses and Dominant Strategies

A **dominant strategy** for player 1 is a strategy that is a best response to every strategy of player 2.

| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

# Best Responses and Dominant Strategies

A **dominant strategy** for player 1 is a strategy that is a best response to every strategy of player 2.
A **strictly dominant strategy** for player 1 is a strategy that is a strict best response to every strategy of player 2.

| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
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# Best Responses and Dominant Strategies

A **dominant strategy** for player 1 is a strategy that is a best response to every strategy of player 2.
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| | | **Player 2** | |
|---|---|---|---|
| | | **S1** | **S2** |
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Does player 2 have a strictly dominant strategy?

# Best Responses and Dominant Strategies

A **dominant strategy** for player 1 is a strategy that is a best response to every strategy of player 2.
A **strictly dominant strategy** for player 1 is a strategy that is a strict best response to every strategy of player 2.

| | | Player 2 | |
|---|---|---|---|
| | | **S1** | **S2** |
| **Player 1** | **S1** | -4, -4 | 0, -10 |
| | **S2** | -10, 0 | -1,-1 |

Does player 2 have a strictly dominant strategy?
Yes. We checked that S1 was a strict best response to S1.
Since $P_2(S2,S1) = 0$ and $P_2(S2,S2) = -1$, then S1 is also a strict best response by player 2 to strategy S2 by player 1.

# A New Product

- Two firms are planning to produce a new product.

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| | | **Firm 2** | |
|---|---|---|---|
| | | **LP** | **US** |
| **Firm 1** | **LP** | | |
| | **US** | | |

# A New Product

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| | | **Firm 2** | |
|---|---|---|---|
| | | **LP** | **US** |
| **Firm 1** | **LP** | | .6, .4 |
| | **US** | .4, .6 | |

# A New Product

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| | | **Firm 2** | |
|---|---|---|---|
| | | **LP** | **US** |
| **Firm 1** | **LP** | .6*.8, .6*.2 | .6, .4 |
| | **US** | .4, .6 | |

# A New Product

- Two firms are planning to produce a new product.
- Choice between an up-scale (US) and low-priced (LP) version of the product.
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| | | **Firm 2** | |
|---|---|---|---|
| | | **LP** | **US** |
| **Firm 1** | **LP** | .6*.8, .6*.2 | .6, .4 |
| | **US** | .4, .6 | .4*.8, .4*.2 |

# A New Product

- Two firms are planning to produce a new product.
- Choice between an up-scale (US) and low-priced (LP) version of the product.
- 60% of population prefers the low-priced version and 40% prefers the upscale version.
- Firm 1 is more popular, so it gets 80% of sales when competing for same market segment as Firm 2, and Firm 2 gets 20%.

| | | **Firm 2** | |
|---|---|---|---|
| | | **LP** | **US** |
| **Firm 1** | **LP** | .48, .12 | .6, .4 |
| | **US** | .4, .6 | .32, .08 |