

A Multi-Agent Collaborative Reasoning Framework for Generating Physics

Example Output

In this supplementary material, we provide a complete sample response generated by GPT-4o on one puzzle generation task. This response illustrates the model's ability to autonomously create a puzzle based on a given prompt, detailing its thought process, actions, and observations at each step. This example is provided to illustrate the model's step-by-step reasoning and decision-making throughout the task.

Prompt: Design a puzzle where the blue ball on the right needs to push the red ball down to the goal on the left.

Thought: I am at step 1. I need to call the designer agent to create a new puzzle based on the provided prompt.

Action: call_designer

Action Input: {'prompt': 'Design a puzzle where the blue ball on the right needs to push the red ball down to the goal on the left.'}

Observation: The prompt "Design a puzzle where the blue ball on the right needs to push the red ball down to the goal on the left." clearly asks to design a new puzzle. The input is an empty string.

Part A:

Identify Required Objects and Their Coordinates:

- **Blue Ball (marker_ball):** This ball will be placed on the right side of the environment.
- **Red Ball (target):** This ball will be placed higher than the goal and on the left side of the environment.
- **Goal (green):** This will be placed on the left side of the environment, below the red ball.

2. **Determine Coordinates:**

- **Blue Ball:** Since it needs to be on the right, let's place it at $\backslash (0.5, 0.7) \backslash$
- **Red Ball:** This needs to be higher than the goal and on the left. Let's place it at $\backslash (-0.5, 0.3) \backslash$.
- **Goal:** This needs to be below the red ball and on the left. Let's place it at $\backslash (-0.5, -0.5) \backslash$.

3. **Ensure Unique Coordinates:**

- The coordinates chosen for the blue ball, red ball, and goal are unique and follow the rules.

Final Coordinates:

- **Blue Ball:** $\backslash (0.5, 0.7) \backslash$
- **Red Ball:** $\backslash (-0.5, 0.3) \backslash$
- **Goal:** $\backslash (-0.5, -0.5) \backslash$

By following these coordinates, the puzzle will be designed such that the blue ball on the right needs to push the red ball down to the goal on the left.

Thought: I am at step 2. I need to place the red ball, blue ball, and goal according to the designer agent's initial layout.

Action: place_red_ball_blue_ball_goal

Action Input: {'red_ball': [-0.5, 0.3], 'blue_ball': [0.5, 0.7], 'goal': [-0.5, -0.5]}

Observation: The red ball and goal are on the same x-axis. Please place again by adjusting the x coordinate of either one a little bit without calling the designer.

[illegible]

Thought: I am at step 5. I need to call the solver to determine the next tool placement to assist the blue ball in reaching the red ball.

Action: call_solver

Action Input: {}

Observation: ### Objects and Their Positions

- **Blue Ball**: Initially at (0.5, 0.6587301587301586)

- **Red Ball**: Initially at (-0.5, 0.2880952380952384)

- **Goal**: Positioned at (-0.6, -0.5)

Question 1

Given the message and the trajectories:

- The blue ball has not reached the red ball.

- The red ball has not reached the goal.

- The red ball is on the right of the blue ball in the beginning.

- The red ball is below the blue ball in the beginning.

- The red ball is on the right of the blue ball in the end.

- The red ball is above the blue ball in the end.

Since the red ball is below the blue ball in the beginning, you do not need a cannon. The blue ball needs to move to the right to reach the red ball.

Tool Choice: Ramp

Direction: Right

Placement: The ramp should be placed to the right of the blue ball and the closest object, which is the red ball.

Question 2

There are no orange tools placed in the environment.

Question 3

The red ball is on the right side of the last placed tool (ramp).

Since the blue ball is moving to the right and the red ball is on the right of the tool, the last placed tool indeed makes the blue ball move toward the red ball.

Question 4

In the last few frames before the blue ball disappears on the screen, you need to use a tool to help the blue ball change its moving direction toward the red ball.

Tool Functions:

- **Ramp**: Simulates inclined surfaces over which balls can roll or slide down to change direction to the left or right. Used for gradual changes in direction or to guide the ball smoothly over a distance. Lengths: 10, 14, 18.

- **Fixed_Hexagon**: Redirects the ball toward another direction. Cannot be placed when there are no other tools and when the blue ball is falling vertically down.

- **Cannon**: Used to shoot the ball in a specific direction.

The red ball is on the right of the blue ball in the end. The blue ball needs to move to the right.

Tool Choice: Ramp

Direction: Right

Placement: The ramp should be placed to the right of the red ball and the closest object to the blue ball at this point.

Question 5

Since the red ball is on the right of the blue ball in the end, the tool should be placed on the left of the red ball. If the blue ball is at the bottom of the other object, then the tool should be placed at the bottom of the other object.

Placement: The ramp should be placed to the left of the red ball and the closest object to the blue ball at this point.

Thought: I am at step 6. I need to place a ramp to assist the blue ball in reaching the red ball. The ramp should be placed to the right of the blue ball and the closest object, which is the red ball.

Action: place_ramp

Action Input: {'first_obj': 'blue_ball', 'direction1': 'right', 'second_obj': 'red_ball', 'direction2': 'left', 'blue_ball_moving_direction': 'right', 'length': 14}

Observation: ('A ramp has been placed at [63.0, 63.0] with an angle of 30 degrees and a length of 18 units.', 'I must go to next step to visualize the simulation.')

Thought: I am at step 7. I need to visualize the environment after placing the ramp to see if the blue ball reaches the red ball.

Action: visualize_simulation

Action Input: {}

Observation: (return trajectory information)

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Thought: I am at step 8. The blue ball has not reached the red ball yet. I need to call the solver again to determine the next tool placement to assist the blue ball in reaching the red ball.

Action: call_solver

Action Input: {}

Observation: (answer from the solver agent)

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Thought: I am at step 6. I need to place another ramp to assist the blue ball in reaching the red ball. The ramp should be placed to the right of the blue ball and below the red ball.

Action: place_ramp

Action Input: {'first_obj': 'blue_ball', 'direction1': 'right', 'second_obj': 'red_ball', 'direction2': 'bottom', 'blue_ball_moving_direction': 'right', 'length': 14}

Observation: ('A ramp has been placed at [63.0, 63.0] with an angle of 30 degrees and a length of 18 units.', 'I must go to next step to visualize the simulation.')

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(Iterate through visualize_simulation, call_solver, place tools for three times)

Thought: I am at step 9. The blue ball has not reached the red ball and I have already called the solver three times. I need to call the designer to determine the red ball's new position such that the red ball can be on the blue ball's trajectory.

Action: call_designer

Action Input: {'prompt': "Propose a new position for the red ball such that the red ball can be on the blue ball's trajectory."}

Observation: The prompt "Propose a new position for the red ball such that the red ball can be on the blue ball's trajectory." is asking to adjust the position of the red ball so that it intersects with the path of the blue ball, ensuring a collision.

Given the input:

- The blue ball has not reached the red ball.
- The red ball has not reached the goal.
- The red ball is on the right of the blue ball in the beginning.
- The red ball is below the blue ball in the beginning.
- The red ball is on the left of the blue ball in the end.
- The red ball is above the blue ball in the end.

The trajectory of the blue ball is:

1. (0.5, 0.6587301587301586)
2. (0.4699988634804402, 0.6186268877024894)
3. (0.40920907323243183, 0.5835298859388207)
4. (0.3239811763520588, 0.5343235367324712)
5. (0.2157240901228732, 0.46696198287597124)
6. (0.10214117990762439, 0.3303582991438698)
7. (-0.011441730307624631, 0.10909853075568376)
8. (-0.12502464052287343, -0.1968173222885865)
9. (-0.23860755073812234, -0.5873892599889413)

The trajectory of the red ball is:

1. (-0.5, 0.2880952380952384)
2. (-0.5, 0.2852249710648149) - remains at this position.

The goal is placed at: [-0.6, -0.5].

Part B: Adjusting Object Positions

1. Analyze the blue ball's trajectory:

- The blue ball moves right and down through the following coordinates:

- (0.5, 0.6587301587301586)
- (0.4699988634804402, 0.6186268877024894)
- (0.40920907323243183, 0.5835298859388207)
- (0.3239811763520588, 0.5343235367324712)
- (0.2157240901228732, 0.46696198287597124)
- (0.10214117990762439, 0.3303582991438698)
- (-0.011441730307624631, 0.10909853075568376)
- (-0.12502464052287343, -0.1968173222885865)
- (-0.23860755073812234, -0.5873892599889413)

2. Propose a new position for the red ball:

- To ensure a collision, the red ball should be placed on one of the blue ball's trajectory coordinates.
- A suitable position for the red ball could be at (0.102, 0.330), which is on the blue ball's trajectory.

3. Special Condition - Cannon:

- There is no indication that a cannon is involved in this scenario.

4. Direction of the blue ball:

- The blue ball needs to move to the right to reach the red ball, as the red ball is initially on the right of the blue ball.

Action:

- Adjust the red ball's position to (0.102, 0.330).

By following these steps, the red ball will be on the blue ball's trajectory, ensuring a collision.

Thought: I need to adjust the red ball's position to (0.102, 0.330) to ensure it is on the blue ball's trajectory.

Action: adjust_red_ball_position

Action Input: {'x': 0.102, 'y': 0.33}

Observation: Red ball position adjusted successfully.

Thought: I am at step 11. I need to visualize the environment after adjusting the red ball's position to see if the blue ball reaches the red ball.

Action: visualize_simulation

Action Input: {}

Observation: (The following sentences describe the relative positions of the tool to the objects in the environment to help you better understand the spatial relationships shown in the image: The red ball is on the right of the tool. The goal is on the right of the tool., 'the blue ball has successfully reached the red ball. The red ball has reached the goal. The red ball is on the right of the blue ball in the beginning. The red ball is below the blue ball in the beginning. The red ball is on the right of the blue ball in the end. The red ball is below the blue ball in the end. The trajectory of the blue ball is: The blue ball is at (0.5, 0.6587301587301586) now. It moves to the right and down at (0.4699988634804402, 0.6186268877024894). The blue ball is at (0.4699988634804402, 0.6186268877024894) now. It moves to the right and down at (0.40920907323243183, 0.5835298859388207). The blue ball is at (0.40920907323243183, 0.5835298859388207) now. It moves to the right and down at (0.3239811763520588, 0.5343235367324712). The blue ball is at (0.3239811763520588, 0.5343235367324712) now. It moves to the right and down at (0.2157240901228732, 0.46696198287597124). The blue ball is at (0.2157240901228732, 0.46696198287597124) now. It moves to the right and down at (0.10214117990762439, 0.3303582991438698). The blue ball is at (0.10214117990762439, 0.3303582991438698) now. It moves to the left and up at (0.13082016128907492, 0.4810042795646865). The blue ball is at (0.13082016128907492, 0.4810042795646865) now. It moves to the left and up at (0.1631237891273818, 0.5564920940928313). The blue ball is at (0.1631237891273818, 0.5564920940928313) now. It moves to the left and down at (0.19542741696568866, 0.5473238239648919). The blue ball is at (0.19542741696568866, 0.5473238239648919) now. It moves to the left and down at (0.2190007626758994, 0.46583121402475647). The blue ball is at (0.2190007626758994, 0.46583121402475647) now. It moves to the right and down at (0.18146213348943685, 0.38600473333575924). The blue ball is at (0.18146213348943685, 0.38600473333575924) now. It moves to the right and down at (0.1439235043029743, 0.22152216799067714). The blue ball is at (0.1439235043029743, 0.22152216799067714) now. It moves to the right and up at (0.10443219166643036, 0.2232588126225663). The blue ball is at (0.10443219166643036, 0.2232588126225663) now. It moves to the right and up at (0.06420020599709697, 0.23512972492473683). The blue ball is at (0.06420020599709697, 0.23512972492473683) now. It moves to the right and down at (0.02396822032776358, 0.16659516055525825). The blue ball is at (0.02396822032776358, 0.16659516055525825) now. It moves to the right and up at (-0.016263765341569703, 0.1791782229226917). The blue ball is at (-0.016263765341569703, 0.1791782229226917) now. It moves to the right and down at (-0.056495751010902984, 0.16543627855844223). The blue ball is at (-0.056495751010902984, 0.16543627855844223) now. It moves to the right and down at (-0.09672773668023638, 0.16520848001532462). The blue ball is at (-0.09672773668023638, 0.16520848001532462) now. It moves to the right and down at (-0.13695972234956977, 0.16520848001066102). The blue ball is at (-0.13695972234956977, 0.16520848001066102) now. It moves horizontally to the right at (-0.17719170801890305, 0.16520848001066102). The blue ball is at (-0.17719170801890305, 0.16520848001066102) now. It moves to the right and down at (-0.2184075732193278, 0.16041458563965105). The blue ball is at (-0.2184075732193278, 0.16041458563965105) now. It moves to the right and down at (-0.26644567418043386, 0.12496502689856137). The blue ball is at (-0.26644567418043386, 0.12496502689856137) now. It moves to the right and down at (-0.3159916675723612, 0.015925729314669734). The blue ball is at (-0.3159916675723612, 0.015925729314669734) now. It moves to the right and down at (-0.3655376609642884, -0.1777696529253061). The trajectory of the red ball is: The red ball is at (0.0020000000000000018, 0.16809523809523808) now. It moves vertically down at (0.0020000000000000018, 0.16522497106481482). The red ball is at (0.0020000000000000018, 0.16522497106481482) now. It remains at the same position. The red ball is at (0.0020000000000000018, 0.16522497106481482) now. It remains at the same position. The red ball is at (0.0020000000000000018, 0.16522497106481482) now. It remains at the same position. The red ball is at (0.0020000000000000018, 0.16522497106481482) now. It remains at the same position. The red ball is at (0.0020000000000000018, 0.16522497106481482) now. It moves to the right and down at (-0.04551249012647962, 0.16522486772486777). The red ball is at (-0.04551249012647962, 0.16522486772486777) now. It moves horizontally to the right at (-0.09422015487724589, 0.16522486772486777). The red ball is at (-0.09422015487724589, 0.16522486772486777) now. It moves horizontally to the right at (-0.14292781962801215, 0.16522486772486777). The red ball is at (-0.14292781962801215, 0.16522486772486777) now. It moves to the right and down at (-0.19163623068769975, 0.1651806595972818). The red ball is at (-0.19163623068769975, 0.1651806595972818) now. It moves to the right and down at (-0.24282133876626655, 0.14822103935407105). The red ball is at (-0.24282133876626655, 0.14822103935407105) now. It moves to the right and down at (-0.2968531650705072, 0.07219594731644419). The red ball is at (-0.2968531650705072, 0.07219594731644419) now. It moves to the right and down at (-0.35087154004279564, -0.08809689415249367). The red ball is at (-0.35087154004279564, -0.08809689415249367) now. It moves to the right and down at (-0.4048899150150841, -0.3330458202775157). The red ball is at (-0.4048899150150841, -0.3330458202775157) now. It moves to the right and down at (-0.4610661126165171, -0.45893044366070723). The red ball is at (-0.4610661126165171, -0.45893044366070723) now. It moves to the right and up at (-0.520479044161667, -0.36555650969872533). The red ball is at (-0.520479044161667, -0.36555650969872533) now. It moves to the right and up at (-0.5798919757068168, -0.3568386603928281). The red ball is at (-0.5798919757068168, -0.3568386603928281) now. It moves to the right and down at (-0.6393049072519668, -0.4327768957430156). The red ball is at (-0.6393049072519668, -0.4327768957430156) now. It moves to the right and down at (-0.6987178387971166, -0.48671984997280227). The red ball is at (-0.6987178387971166, -0.48671984997280227) now. It moves to the right and up at (-0.7581307703422664, -0.4810258645728409). The red ball is at (-0.7581307703422664, -0.4810258645728409) now. It moves to the right and down at (-0.8183506494023641, -0.5061255513555094). The red ball is at (-0.8183506494023641, -0.5061255513555094) now. It moves to the right and down at (-0.8796622809826848, -0.5430086470948827). The red ball is at (-0.8796622809826848, -0.5430086470948827) now. It moves to the right and down at (-0.9409739125630056, -0.664547827490341). The goal is on the left of the red ball in the end. The goal is placed at: [-0.6, -0.5].')

Thought: The puzzle has successfully created. The blue ball has successfully reached the red ball, and the red ball has reached the goal.

Answer: The puzzle is successfully created.

