

24.118: Paradox and Infinity, Spring 2019

Problem Set 4: Time Travel

How these problems will be graded:

- In Part I there is no need to justify your answers. Assessment will be based on whether your answers are correct.
- In Part II you must justify your answers. Assessment will be based both on whether you give the correct answer and on how your answers are justified. (In some problem sets I will ask you to answer questions that don't have clear answers. In those cases, assessment will be based entirely on the basis of how your answer is justified. Even if it is unclear whether your answer is correct, it should be clear whether or not the reasons you have given in support of your answer are good ones.)
- *No answer may consist of more than 150 words.* Longer answers will not be given credit. (Showing your work in a calculation, a proof, or a computer program does not count towards the word limit.)
- You may consult published literature and the web. You must, however, credit all sources. Failure to do so constitutes plagiarism and can have serious consequences. For advice about when and how to credit sources see: <https://integrity.mit.edu/> (You do not need to credit course materials.)

Part I

1. Recall that for a time-travel story to be consistent, it must never give us conflicting descriptions of a single point in the narrative's timeline.

With that in mind, determine whether each of the the following stories can be interpreted as a consistent time travel stories. (Make sure you interpret them as stories about ordinary time, rather than super-time, and that you interpret them as time travel stories rather than world-travel stories.)

- (a) After doing badly in an exam, you resolve to travel back in time to give yourself a hint before the exam takes place. You successfully travel back in time but mistakenly hand your earlier self the wrong hint and end up doing even worse on the exam. (5 points)
- (b) As a child, Oscar goes for a walk in the forest. For a few seconds, he experiences the odd sensation of being watched. Many years later, he uses a time machine to travel back to that fateful day. He finds good a hiding place in the forest and spends a few seconds watching his younger self. As an old man, he again uses a time machine to travel back to the fateful day. He finds an even better hiding

place and spends a few seconds watching his middle-aged self watch his younger self. (5 points)

- (c) A team of lepidopterists travels back in time to the Paleogene, hoping to catch a glimpse of early butterflies. The team is cautioned not to interfere with the past in any way. But accidents happen. As they are completing their journey, one of the scientists steps on a branch and startles a butterfly. When the team returns to the present, they are confronted with a changed world. Land octopuses have conquered the Earth and rule with an iron tentacle. A small interference in the past has made a big difference to the future. (5 points)

Part II

2. Recall the Control Hypothesis:

Control Hypothesis An agent acts freely in doing X if and only if: (1) she does X by making a certain decision, and (2) she is in a position to do something other than X by making a different decision.

Now consider the following scenarios:

- (a) Felix is on his way to get ice-cream. You know Felix well enough to know that the only ice-cream flavor he likes is chocolate. So you know from the start that he will choose chocolate. And sure enough: when he arrives at the ice-cream store he chooses chocolate, even though he was in a position to choose any flavor on the menu.

According to the Control Hypothesis, did Felix act freely in choosing chocolate? Keep in mind that you were able to predict that he would pick chocolate from the start. (5 points; don't forget to justify your answer)

- (b) Bruno is on his way to kill Grandfather. You know that Grandfather is Bruno's grandfather.¹ So you know from the start that Bruno will fail. And sure enough: Bruno has a change of heart at the last minute and decides to put down the gun, even though he was in a position to make a different decision and pull the trigger instead.

According to the Control Hypothesis, did Bruno act freely in putting down his gun? Keep in mind that you were able to predict that he wouldn't kill Grandfather from the start. (5 points; don't forget to justify your answer)

- (c) After several hours of good fun, you decide to leave the party early and spend the rest of the evening at home. Unbeknownst to you, your hosts were finding your jokes extremely obnoxious and were about to

¹Also, you know that there is no funny business: no rising up from the dead, no frozen sperm, no replicated DNA, etc.

kick you out just as you left. So, had you instead decided to stay a little longer, you wouldn't have been able to: you would have been forced to leave early anyway.

According to the Control Hypothesis, did you act freely in leaving the party early? Is that answer intuitively correct?

3. To causally explain how event x occurs (or why it occurs) is to describe a sequence of causes and effects leading to x 's occurrence. The following two questions concern causal explanations.

- (a) On your 21st birthday, an elderly stranger hands you a nautically themed clock. The clock is strikingly beautiful—mesmerizing, even. Many years later, in your old age, you travel back in time to your 21st birthday and hand the clock to your younger self.

On the basis of the information you have been given so far, is there a causal explanation to be given about how the clock was originally built? If so, spell it out. If not, explain why not. (10 points)

- (b) Olivia travels to the past in an effort to kill her grandfather before he has any children. On pain of contradiction, Olivia will not succeed.²

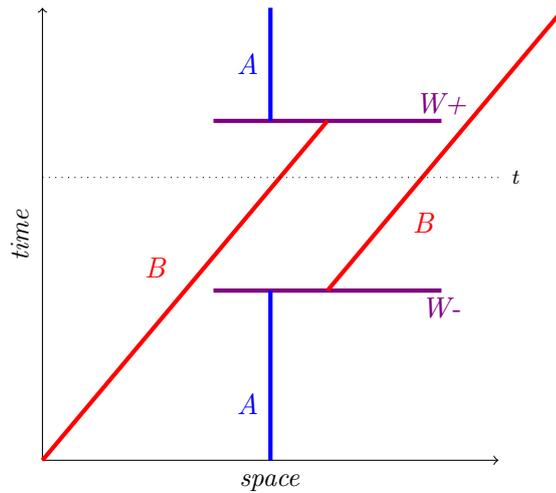
On the basis of the information you have been given so far, is there a causal explanation to be given about why Olivia fails? If so, spell it out. If not, enrich the story so that it entails a suitable explanation. (10 points)

4. You're wondering whether to study for tomorrow's biology exam. It's a hard exam and you won't pass unless you study. Just then you see your good friend Amy emerge from a time machine. She announces that she's been to the future and has seen you pass the exam. In fact, she took a picture of the graded exam with her phone. You glance at the screen and see an A+ scribbled with a red marker.

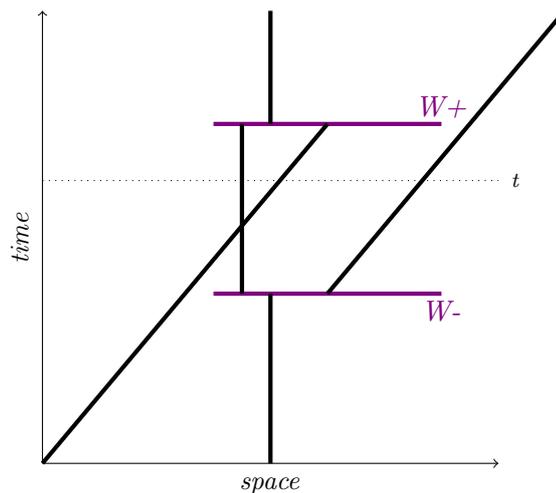
Amy is totally reliable, so you can be 100% confident that you will pass the exam. Does that mean that you'll pass even if you don't study? (10 points; don't forget to justify your answer.)

5. Section 4.3.1 of the course materials discusses a toy model of time travel. The diagram below depicts a wormhole within the world of the toy model. The points represented by W^- are identified with the points represented by W^+ . Particle A jumps to the future when its spacetime trajectory reaches the wormhole from outside the wormhole region; particle B jumps to the past when its spacetime trajectory reaches the wormhole from inside the wormhole region.

²As usual, I am assuming no funny business: no rising up from the dead, no frozen sperm, no replicated DNA, etc.



Note that only one particle—particle B —exists at time t , though B experiences time t twice. Now consider a different diagram:



Assuming the laws of the toy model are in place, how many different particles exist at time t ? (20 points; don't forget to explain your answer)

6. There is a famous scene in the film *The Matrix* in which the Oracle predicts that Neo will break a vase. (You can find it online by searching “matrix oracle vase”.³)
 - (a) Describe a consistent time travel story that uses time travel to explain how the Oracle acquires the information necessary to issue her successful prediction. (10 points)

³Or you can go here: <https://www.youtube.com/watch?v=eVF4kebiks4>

- (b) Neo breaks the base after turning back. Does the Control Hypothesis entail that, according to the story you gave in your response to (6a), Neo fails to act freely in turning back? (10 points)

* * *

Optional

Is contemporary physics compatible with time travel? Alan Guth, who is a famous physicist at MIT, tackled this question during a visit to *Paradox and Infinity*, a few years ago. You can check out his lecture here: <https://www.youtube.com/watch?v=t5AwyxCZIwE>

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