

Assignment #2

Readings:

- Moore - Chapter 3
- Moore - Chapter 4
- Moore - Chapter 5

Supplemental

- Boccio - Relativity 1 - P6
- Boccio - Relativity 2 - P6
- Boccio - Relativity 3 - P6

Summary: This week we will be studying the **three kinds of time, light clocks** and the **spacetime interval** which is an important concept for later discussions, **proper time** and a first look at a so-called **paradox**.

We will start to think about the powerful idea of **invariance**.

This will enable us to continue on the semester's journey into modern theoretical physics.

Everyone Problems:

- M:3-5 TV time
- M:4-6 An exploding rocket
- EP-6 Two clocks
- EP-8 Can you save them?

Individual Problems:

- M:3-4 Out of synch
- M:3-6 The three kinds of time
- M:3-7 The synchronization discrepancy
- M:4-1 The spacetime interval
- M:4-2 The spacetime interval again
- M:4-5 The spacetime interval is frame independent
- M:4-7 Rapid transit
- M:5-1 Relativistic travel
- M:5-5 Jet lag
- M:5-10 The three kinds of time again
- M:5-12 Proof of the binomial approximation
- M:5-14 Doppler shift
- M:5-15 Doppler shift again
- M:5-16 Speeding
- EP-7 More events in different frames

Presentations:

- (1) Three Kinds of Time
- (2) The Spacetime Metric
- (3) The Twin Paradox
- (4) The Doppler Shift

Seminar Break:

Extra Problems:

EP-6 Two clocks Imagine two clocks, P and Q. Both clocks leave the spatial origin of the Home Frame at time $t = 0$: call this the origin

event O. Both clocks move along the +x axis, with clock P originally traveling at a speed of $4/5$, while Q travels at a speed of about $1/5$. After a while, however, clock P decelerates, comes to rest, and then begins to move back towards the origin. A short time later, clock P collides with the slower clock Q, which has been moving with constant speed along the x axis during all of this. Let the collision of the clocks be event A.

(a) Draw a qualitatively accurate spacetime diagram of the story described above, labeling the worldlines of clocks P and Q and the locations of events O and A.

(b) Assume that clocks P and Q were both synchronized with the clock at the origin of the Home Frame when they left the origin. Will P and Q necessarily agree when they collide? Explain.

(c) An observer in the Home Frame measures the time between O and A with a pair of synchronized clocks (one at the spatial location of O and one at the spatial location of A). Clocks P and Q each also register a time between these events.

Which clock(s) measure proper time between the events? The spacetime interval between the events? The coordinate time between the events?

EP-7 More events in different frames In the solar system frame, two events are measured to occur 3.0 hr apart in time and 1.5 hr apart in space. Observers in an alien spaceship measure the two events to be separated by only 0.5 hr in space. What is the time separation between the events in the alien's frame?

EP-8 Can you save them? In 2095 a message arrives at earth from the growing colony at Tau Ceti (11.3 y from earth). The message asks for help in combating a virus that is making people seriously ill (the message includes a complete description of the virus genome). Using advanced technology available on earth, scientists are quickly able to construct a drug that prevents the virus from reproducing.

You have to decide how much of the drug can be sent to Tau Ceti.

The space probes available on short notice could either boost 200 g of drug (in a standard enclosure) to a speed of 0.95, 1 kg to a speed of 0.90, 5 kg to a speed of 0.80, or 20 kg to a speed of 0.60 relative to the earth.

The only problem is that a sample of the drug in a standard enclosure at rest in the lab is observed to degrade due to internal chemical processes at a rate that will make it useless after 5.0 y.

Is it possible to send the drug to Tau Ceti? If so, how much can you send?