Assess Quizzes from the o-book – Explanations for the answers.

Chapter 9 Review – Support

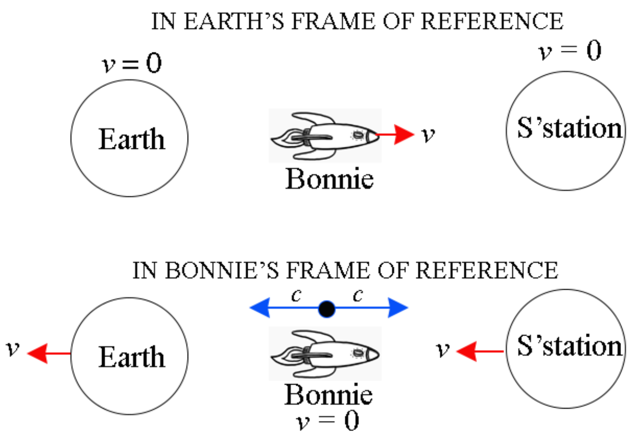
Q	Reason
1	As defined in NCPQ page 250 (sidebar) - or see syllabus page 79. The other options are wrong. Relativistic effects will occur in an inertial frame but may not be noticeable until the speed is high (eg > 0.1 c). An accelerating frame is not inertial as Newton's laws of motion will not make sense. For example, imagine trying to do a pendulum experiment in a car accelerating away from the traffic lights. Lastly, proper time interval will be observed in a frame at rest to the event, which would be an inertial frame of reference, but a frame moving at constant velocity with respect to an observer could also be inertial.
2	Light speed is invariant (in a vacuum). It is always 1.0 c.
3	Read the experiment in NCPQ pages 248-249. The two options about speed are wrong as the speed of the muons was the same to all observers.
4	This is called 'The Light on the Train' paradox. Read all about in in NCPQ pages 258-259. The option that 'the rear door opens first but the front door never does' is partially correct but the front door will also open unless the train is travelling at the speed of light which is impossible for an object with mass.
5	t_0 = 1 s as it is the time for the life of a particle measured in the frame of reference of the particle. In other words, in the frame of reference when the particle is at rest. Hence, it is proper time. The observer in the lab measures relativistic or 'dilated' time as the particle is moving with respect to the observer. $t = \frac{t_0}{\sqrt{1-v^2/c^2}} = \frac{t_0}{\sqrt{1-(0.6c)^2/c^2}} = \frac{t_0}{\sqrt{1-0.6^2}} = \frac{1}{0.8} = 1.25\,s$
6	Without looking outside you can't tell if you're moving. Read NCPQ p 252. The option that you can compare it to a beam of light is incorrect as you will always observe a beam of light to move at the same speed, no matter what you are doing. The option about space being a vacuum is only true in so far as the (interstellar) space between stars. Nevertheless, you could measure your speed compared to the stars. The option about the angle a pendulum makes with the vertical may happen for accelerated motion but only where there is a gravitational field that pulls the bob downwards.
7	The front clock's time signal takes longer to get to you than the back clock's signal, so the rear clock shows the later time. The option 'they are both the same' would only be true for an observer at rest to the clocks and midway between them (on the train).
8	Until you get up to speeds over about 0.1c, relativistic effect are not noticeable. See Table 1 page 264 NCPQ.

Assess Quizzes from the o-book – Explanations for the answers.

9	$t=\dfrac{t_0}{\sqrt{1-v^2/c^2}}$ $\sqrt{1-v^2/c^2}=\dfrac{t_0}{t}=\dfrac{0.80}{1.0}$ $1-v^2/c^2=(0.80)^2$ $1-v^2/c^2=0.64$ $v^2/c^2=1-0.64=0.36$ $\dfrac{v}{c}=\sqrt{0.36}=0.60$ $v=0.60c$
10	Light speed is invariant (in a vacuum). It is always 1.0 c.

Chapter 9 Review – Consolidate

Q	Reason
1	That is, travelling along with the pion. You could also say the observer has to be at rest to the pion.
2	$t=\dfrac{t_0}{\sqrt{1-v^2/c^2}}=\dfrac{26\,ns}{\sqrt{1-(0.98)^2}}=\dfrac{26\,ns}{0.199}=131\,ns\approx 130\,ns$
3	Each is observing the time interval on a clock stationary in their own frame of reference, thus they would observe the same time interval.
4	In her frame of reference, Bonnie sees the spaceship coming towards her and so the signal would reach her earlier (similar to the flashlights on the train paradox).



Assess Quizzes from the o-book – Explanations for the answers.

5	Scientists in the lab see the proton moving between the two electrodes so they measure dilated time *t*. In the particle's frame of reference the departure and arrival at the electrodes happens in the same place as the particle sees the two electrodes as being the things that are moving. So the particles sees the time interval as the proper time interval, t_0. $t = \frac{t_0}{\sqrt{1 - v^2/c^2}}$ $t_0 = t\sqrt{1 - v^2/c^2} = 40\sqrt{1 - 0.78^2} = 40 \times 0.626$ $= 25.0\,ns$

Chapter 9 Review – Extend

Q	Reason
1	The only place that is definitely at rest to the clock is aboard spacecraft R. In any other frame the clock could appear to be moving.
2	The signal was sent back to Earth immediately it arrived at spacecraft R. It took 20.0 ms for the round trip so it took 10.0 ms to get there and 10.0 ms to get back. The spacecraft R's distance can be calculated: $s = vt = 3 \times 10^8 \times (10 \times 10^{-3}) = 3 \times 10^6\ m = 3000\,km$ R is exactly 3000 km away – not more than 3000 km away. Earth measures the start and finish of the radio pulse from the same place so measures proper time (t_0). R measures dilated time (t) as the event (start and finish of the pulse) is an event that occurs in a frame moving relative to R, and as $t > t_0$, the time must be >20ms for R.
3	R measures t_0 as the clock aboard R is in the same place for the start and finish of the event, so R measures proper time t_0. S measures dilated time (t) as the clock is in a different place at the start than at the finish. $t = \frac{t_0}{\sqrt{1 - v^2/c^2}}$ $\sqrt{1 - v^2/c^2} = \frac{t_0}{t} = \frac{1.0}{1.2} = 0.833$ $1 - v^2/c^2 = (0.833)^2$ $1 - v^2/c^2 = 0.694$ $v^2/c^2 = 1 - 0.694 = 0.306$ $\frac{v}{c} = \sqrt{0.306} = 0.55$ $v = 0.55c$

Assess Quizzes from the o-book – Explanations for the answers.

4	The time of 1.00 s in the frame of the nucleus must be proper time (t_0). The observers see it moving so they measure dilated time (t) as the event of splitting in two occurs in two different places. $t = \frac{t_0}{\sqrt{1 - v^2 / c^2}}$ $\sqrt{1 - v^2 / c^2} = \frac{t_0}{t} = \frac{1.00}{1.5} = 0.667$ $1 - v^2 / c^2 = (0.667)^2$ $1 - v^2 / c^2 = 0.444$ $v^2 / c^2 = 1 - 0.444 = 0.555$ $\frac{v}{c} = \sqrt{0.555} = 0.75$ $v = 0.75c$
5	Arthur is at rest to the doors and they are at equal distances from him so the light will take the same time to get to the doors. We can rule out all other options. Arthur does not see the distances contract as he is at rest to them. Bob may see the rear door open first as it moves towards the light, as the front door moves away from the light. But that is true for Bob, but not for Arthur.