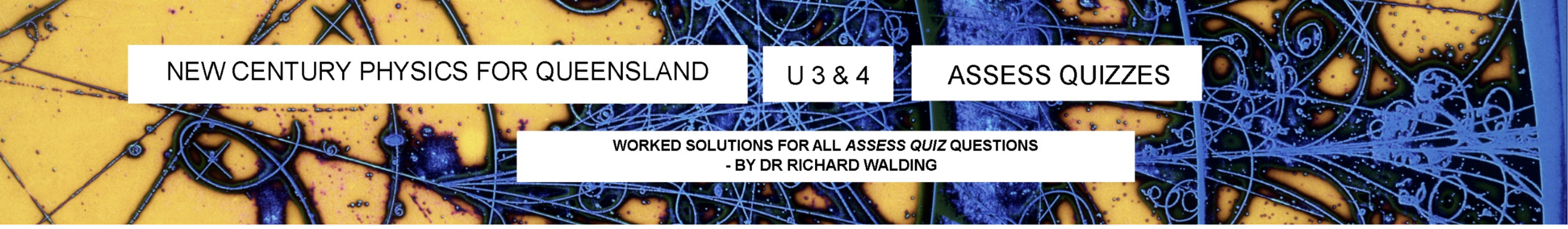


NEW CENTURY PHYSICS FOR QUEENSLAND

U 3 & 4

ASSESS QUIZZES

WORKED SOLUTIONS FOR ALL *ASSESS QUIZ* QUESTIONS
- BY DR RICHARD WALDING

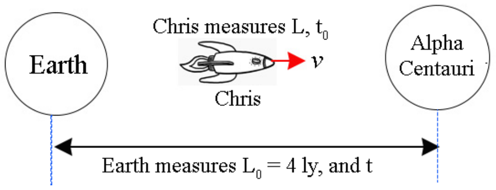
Assess Quizzes from the o-book – Explanations for the answers.

Chapter 10 Review – Support

Q	Reason
1	The laws of physics are the same in all inertial frames of reference. See Postulate 1 page 251 NCPQ. The other options are not postulates of Einstein's relativity. For instance, $E = mc^2$ is true but is derived from other work. The option about nothing moving faster than the speed of light is only true in a vacuum, so while it is almost correct it is not exact.
2	Train has a rest length $L_0 = 200.0$ m, platform has a $L_0 = 160.0$ m. Don't be tricked into thinking the 160.0 m is the contracted length of the train. It is set there as a trap by me. The train does contract to 160.0 m to match the rest length size of the platform. So $L_{train} = 160.0$ m. $L = L_o\sqrt{1-v^2/c^2}$ $160 = 200\sqrt{1-v^2/c^2}$ $\frac{160}{200} = \sqrt{1-v^2/c^2}$ $0.80 = \sqrt{1-v^2/c^2}$ $0.64 = 1-v^2/c^2$ $0.36 = v^2/c^2$ $\sqrt{0.36} = \frac{v}{c}$ $v = 0.60c$
3	The observer aboard Y is at rest to the front and back of the spaceship so will accurately measure its length. The observer at the midpoint would get the same time for light going to the front as to the back, so the difference in times would be zero. The observer on X would not be at rest to the front and rear of the spaceship and could see the front and rear either approaching the light or moving away from it. Not good.
4	At the speed of light, the momentum of an object would be infinite. The formula $p_v = \frac{m_0 v}{\sqrt{1-v^2/c^2}}$ shows that when v = c, the denominator equals zero so the value of p is mv/0 which is infinity. Newtonian momentum doubles when speed is doubled, but not relativistic momentum ($v > 0.1c$). At low speed Newtonian momentum is a little bit less than relativistic momentum. Try the formula to see.
5	This is the relationship for the equation. See NCPQ U3&4 page 282.
6	$E = mc^2 = 2.0\times(3\times10^8)^2$

Explanations for Unit 3 & 4 "Assess Quizzes" in Oxford University Press *New Century Physics for Queensland* Units 3 & 4 Teacher obook assess ISBN 9780190313685. Permission has been granted for this page to be distributed within an individual school only. OUP does not endorse material on this page.

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

7	$p_v = \dfrac{m_0 v}{\sqrt{1 - v^2/c^2}}$ $= \dfrac{9.109\times10^{-31}\times0.985\times3\times10^{8}}{\sqrt{1-(0.985)^2}} = \dfrac{2.691\times10^{-22}}{0.1725}$ $= 1.56\times10^{-21}\, kg\, m\, s^{-1}$
8	Both postulates mention inertial frames of reference. See NCPQ U3&4 page 251. The option ‘a non-accelerated frame of reference’ implies a constant *v*, therefore the laws of inertia hold. It is correct but not the definition used by Einstein in his two postulates. The other option is better.
9	 L is the contracted length, therefore L < L_0 so Chris measures the distance to be shorter than 4 ly. We also know that t > t_0 so Chris measures the shorter time t_0.
10	Moving clocks run slow, so the clocks aboard the spaceship would appear to us, as stationary observers, to run slower than ours.

Chapter 10 Review – Consolidate

Q	Reason
1	$\Delta E = \Delta m c^2$ $\Delta m = \dfrac{\Delta E}{c^2} = \dfrac{10.0}{(3\times10^{8})^2} kg$

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2	$L = L_o - 0.010$ $= 2.000 - 0.010$ $= 1.990\,m$ $L = L_o\sqrt{1 - v^2/c^2}$ $\frac{L}{L_o} = \sqrt{1 - v^2/c^2}$ $\frac{1.990}{2.000} = \sqrt{1 - v^2/c^2}$ $0.995 = \sqrt{1 - v^2/c^2}$ $0.995^2 = 1 - v^2/c^2$ $0.990 = 1 - v^2/c^2$ $v^2/c^2 = 1 - 0.990025$ $v^2/c^2 = 0.009975$ $v/c = 0.09987$ $v = 0.09987c\ (\approx 0.10c)$
3	L_0 train = 100 m; L_0 platform = 60 m. The observer on the platform measures the length of the train (in motion) to be 60 m. This is the relativistic (contracted) length of the train (L_{train} = 60 m). $L = L_o\sqrt{1 - v^2/c^2}$ $\frac{L}{L_o} = \sqrt{1 - v^2/c^2}$ $\frac{60}{100} = \sqrt{1 - v^2/c^2}$ $0.60 = \sqrt{1 - v^2/c^2}$ $0.60^2 = 1 - v^2/c^2$ $0.36 = 1 - v^2/c^2$ $v^2/c^2 = 1 - 0.36$ $v^2/c^2 = 0.64$ $v/c = 0.80$ $v = 0.80c$

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

4	$\dfrac{p_{relativistic}}{p_{newtonian}} = \dfrac{p_v}{p} = \dfrac{\dfrac{m_0 v}{\sqrt{1-v^2/c^2}}}{mv} = \dfrac{1}{\sqrt{1-v^2/c^2}}$ $\sqrt{1-v^2/c^2} = 0.5$ $1-v^2/c^2 = 0.25$ $v^2/c^2 = 0.75$ $v = 0.87\,c$
5	The time for the radio signal to go from Castor to Pollux is 0.0100 s. Hence, the distance apart in Castor's frame of reference is given by: $s = ct = 3\times10^8\times0.0100 = 3\times10^6\,m$ $= 3000\,km$ Note: the fact that both spacecraft are moving is immaterial. It is light that is moving, and this is independent of the speed of source or receiver. Castor knows that light travels at 3 × 10^8 m s^{-1} and that it took 0.0100 s to get to Castor, so the distance is simple to work out as shown above. If you wanted to work out the relative speed of Pollux to Castor, you can't just add 0.4 c to 0.6 c and get 1.0 c. You need to use the relativistic addition of velocities formula (NCPQ U3&4 page 255). You should get 0.806 c, but this is taking the question outside the syllabus and not what has been asked for.

Chapter 10 Review – Extend

Q	Reason
1	L_0 = 200 m as this length is stationary in the rock's frame of reference. The spacecraft observers would measure the relativistic (contracted) length L. $L = L_o\sqrt{1-v^2/c^2}$ $L = 200\sqrt{1-0.70^2}$ $L = 143\,m$
2	The only observers at rest with respect to the landing area are the observers on the rock, and the observers travelling at the same speed as the rock and hence are at rest with respect to the rock. The probe is doing this.
3	The astronaut is always at rest with respect to the two mirrors (that is, the 'clock'). It doesn't matter if the spacecraft is travelling relative to the galaxy, she is still at rest to the mirrors. You could just picture her spacecraft at rest and the galaxy whizzing by at 0.60 c relative to her.

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

4	The length of the path between the two mirrors is the proper length as they are measured in a frame at rest to the astronaut. When she moves relative to the galaxy, she is still at rest to the mirrors and the distance between them. $L = L_o\sqrt{1-v^2/c^2}$ $L = 5.0\sqrt{1-0.60^2}$ $L = 4.0\,m$ Note: I put too many significant figures in the correct option. It should be 4.0 m, not 4.00 m.
5	$t = \frac{L_0}{c} = \frac{10.0}{3\times10^8} = 3.33\times10^{-8}$ $t = \frac{t_0}{\sqrt{1-v^2/c^2}}$ $= \frac{3.33\times10^{-8}}{\sqrt{1-0.6^2}} = \frac{3.33\times10^{-8}}{0.8}$ $= 4.167\times10^{-8}\,s$ $= 41.67\times10^{-9}\,s$ $= 41.67\,ns\,(\approx 42\,ns)$