PHY4116 From Newton to Einstein Coursework Sheet 8: Time Dilation

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A1) A spaceship flies past Mars with a speed of 0.978c relative to the surface of the planet. When the spaceship is directly overhead at an altitude of 1200km, a very bright signal light on the Martian surface blinks on and then off. An observer on Mars measures that the signal was on for 82.4 µs. What is the duration of the light pulse measured by the pilot of the spaceship? [4]

A2) The negative pion (π^{-}) is an unstable particle with an average lifetime of 2.60 × 10^{-8} s (measured in the rest frame of the pion). a). If the pion is made to travel at very high speed relative to a laboratory, its average lifetime is measured in the laboratory to be 4.20 x 10^{-7} s. Calculate the speed of the pion expressed as a fraction of *c*. b). What distance, measured in the laboratory, does the pion travel during its average lifetime? [5]

B3) As you pilot your space utility vehicle at a constant speed towards the moon, a race pilot flies past you in her spaceracer with a constant speed of 0.8c relative to you. At the instant the spaceracer passes you, both of you start timers at zero. a) At the instant when you measure that the spaceracer has travelled 1.20×10^8 m past you, what does the race pilot read on her timer? b) When the race pilot reads the value calculated in part (a) on her timer, what does she measure to be her distance from you? C). At the instant when the race pilot reads the value calculated in part (a) on her timer? [5]

B4) A spacecraft flies away from the Earth with a speed of 4.80×10^6 m/s relative to the Earth and then returns at the same speed. The spacecraft carries an atomic clock that had been carefully synchronised with an identical clock which remains at rest on the Earth. The spacecraft returns to its starting point 365 days later, as measured by clocks that remained on the Earth. What is the difference in elapsed times on the two clocks, measured in hours? Which clock, the one on the spacecraft or the one on Earth, shows the smallest elapsed time? [3]

A5) An alien spacecraft is flying overhead at a great distance from you. You see its searchlight blink on for 0.19 s. On the spacecraft they measure the searchlight as being on for 12 ms. a). Which of these two times is the proper time? b). What is the speed of the spacecraft relative to the Earth expressed as a fraction of the speed of light? [3]