

Q15 A,C,F Statement (b) is true, as is statement (a), but the truth of (b) is not a *significant* part of the reason for the truth of (a). Both statements may be deduced independently by applying the basic concepts of special relativity instantaneously to the analysis of spatial/temporal relationships in the rotating frame of the turntable.

Q16 A,C,F Statement (b) is true as is statement (a), but the truth of (b) is not a significant part of the reason for the truth of (a). Statement (a) follows from the fact that the position of each of the particles may be described by an equation of the form

$$x(t) = s(0) + v(0)t + gt^2/2$$

where g is a constant, as discussed in Unit 9, Section 3.6. Statement (b) shows that a uniform gravitational field causes such motion to arise, but, even if it did not, statement (a) would still be true (though the equivalence principle would not).

Q17 C,D Statements A and B are supported by Unit 9, Section 5.2 and statement C directly contradicts the text of Unit 9, Section 5.3, which stresses the essential role of centrifugal force in the Eötvös experiment. Statement D contradicts the text of Unit 9, Section 5.4, which indicates that the gravitational binding energy contributes equally to the inertial and gravitational masses of the Earth-Moon system to within one part in a thousand. Statement E is supported by Unit 9, Section 5.4.

Q18 D,E According to Equation 12 of Unit 9, the fractional decrease in frequency of e.m. radiation that rises through a height H is $\Delta f/f = gH/c^2$. For $H = 10^5$ m and $g = 10\text{ m s}^{-2}$, $\Delta f/f = 10^6/(9 \times 10^{16}) = 1.1 \times 10^{-11}$ which is (slightly) more than one part in 10^{11} , as claimed in statement A. Statements B and C are supported by Unit 9, Section 5.5. Statement D is false because the frequency of the radiation must *decrease* when it rises. Statement E is false because the result can be predicted using the transverse Doppler effect and does not really involve gravitation in any way.

Q19 B,E,F That B and E are true follows from the discussion of red (blue) shift in Section 5.5 of Unit 9. That F is true follows from the fact that clocks A and C are at rest in the instantaneous rest frame.

10^{-43} gravity separates
 10^{-35} - 10^{-32} inf.
 10^{-12} - electron/weak
 10^{-6} - nucleon form
 605 - 1600 nuclei form
 10^4 yrs