**Chapter-38**

1. In a laboratory frame of reference, an observer notes that Newton’s second law is valid. Assume forces and masses are measured to be the same in any reference frame for speeds small compared with the speed of light. (a) Show that Newton’s

second law is also valid for an observer moving at a constant speed, small compared with the speed of light, relative to the laboratory frame. (b) Show that Newton’s second law is *not* valid in a reference frame moving past the laboratory frame

with a constant acceleration.

Ans: In the laboratory frame of reference, Newton’s second law is valid: . Laboratory observer 1 watches some object accelerate under applied forces. Call the instantaneous velocity of the object  (the velocity of object *O* relative to observer 1 in laboratory frame) and its acceleration . A second observer has instantaneous velocity  relative to the first. In general, the velocity of the object in the frame of the second observer is



(a) If the relative instantaneous velocity  of the second observer is *constant*, the second observer measures the acceleration

****

This is the same as that measured by the first observer. In this nonrelativistic case, they measure the same forces and masses as well. Thus, the second observer also confirms that 

(b)If the second observer’s frame is accelerating, then the instantaneous relative velocity  is *not constant*. The second observer measures an acceleration of

****

where 

The observer in the accelerating frame measures the acceleration of the mass as being  If Newton’s second law held for the accelerating frame, that observer would expect to find valid the relation  or  (since  and the mass is unchanged in each). But, instead, the accelerating frame observer finds that  which is *not* Newton’s second law.

1. Shannon observes two light pulses to be emitted from the same location, but separated in time by 3.00 *μ*s. Kimmie observes the emission of the same two pulses to be separated in time by 9.00 μs. (a) How fast is Kimmie moving relative to

Shannon? (b) According to Kimmie, what is the separation in space of the two pulses?

Ans: Let Shannon be fixed in reference from S and see the two light-emission events with coordinates *x*1 = 0, *t*1 = 0, *x*2 = 0, *t*2 = 3.00 *µ*s. Let Kimmie be fixed in reference frame S*'* and give the events coordinate , , 

(a) Then we have







(b) The coordinate separation of the events is





The later pulse is to the left of the origin.

1. (a) Find the kinetic energy of a 78.0-kg spacecraft launched out of the solar system with speed 106 km/s by using the classical equation . (b) **What If?** Calculate its kinetic energy using the relativistic equation. (c)  Explain the result of comparing the answers of parts (a) and (b).

Ans: (a) Using the classical equation,



(b) Using the relativistic equation, 



(c) When , the binomial series expansion gives

