In this section of Resonance, *we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.*

! Energy transfer in an elastic collision

One may intuitively feel that in an elastic collision, energy is always transferred from an object of higher to one of lower energy. Interestingly, the physics and mathematics of collisions do not impose such a constraint. It is only necessary and sufficient that in such a process the total energy and momentum be conserved. We give here two examples of such processes to highlight this viewpoint.

In an elastic collision there need not be any energy transfer at all. As an example of this we mention the forward Compton scattering. Here an X-ray photon undergoes 'head on' collision with a static electron and emerges in the same direction without losing any energy to the electron.

Is energy always transferred from an object of higher energy to one of lower energy in an elastic collision?

Interestingly, in such a collision, energy can even be transferred from a body of lower to one of higher energy. Consider for example two mass points A and B with masses 0.5 gm and 1 gm and initial velocities 1cm/sec and 0.9 cm/sec respectively. Sooner or later A will overtake B and in the process collide with it. By the laws of conservation of energy and momentum after the collision, A acquires a velocity of $(13/15) \approx 0.8667$ cm/sec and

B a velocity of (29/30) ≈ 0.9667 cms/sec. Clearly A has slowed down and B has speeded up. In this process thekinetic energy of B which was initially higher than that of A has actually increased after collision!

As a remark we may mention that if we average the values of an ensemble of collisions, then over all the more energetic particles lose energy and the less energetic ones gain energy. This is the statistical origin of equipartition (see *Am.J.Phys.* 62:487, June 1994).

Discussion of question raised in the Classroom section of **Resonance** *Vol.1, No.3.*

? An observer points a torch at a mirror that is moving away at velocity *v*. The frequency of the light is ν_0. The light reflected at normal incidence has a lower frequency ν. A calculation including special relativity, gives the result

$$\nu = \nu_0 \left(\frac{c - v}{c + v}\right)$$

where *c* is the speed of light. Why is this different from the standard Doppler shift formula for a source moving at a velocity *v*? This reads

$$\nu = \nu_0 \left(\frac{c - v}{c + v}\right)^{1/2}$$

Can one speak of a velocity of the image and if so what is it?

This question can be answered in two ways :

From Ritesh Kumar Singh, Ranchi; Mohan Devadass, Bangalore and Akshay Pundle (class XII), New Delhi.

a) From the velocity addition theorem of relativity we get the velocity of the image to be equal to $v' = (2v/(1 + v^2/c^2))$. Plugging this into the standard Doppler effect formula we get the required answer.

From Ritesh Kumar Singh, Ranchi

b) For an observer on the moving mirror the light (from the stationary observer) appears to have a frequency equal to $\nu' = \nu_0[(c - v)/(c + v)]^{1/2}$. Suppose this observer starts flashing light at this frequency ν'. Then the stationary observer will receive it as light of frequency $\nu'' = \nu' \, [(c-v)/(c+v)]^{1/2}$. Hence the result.