Show that the two-body decay of this type must necessarily give an electron of fixed energy and, therefore, cannot account for the observed continuous energy distribution in the β-decay of a neutron or a nucleus (Fig. 6.19).

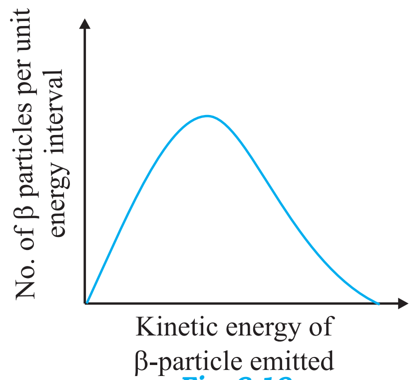

Fig. 6.19

[Note: The simple result of this exercise was one among the several arguments advanced by W. Pauli to predict the existence of a third particle in the decay products of β-decay. This particle is known as neutrino. We now know that it is a particle of intrinsic spin ½ (like e^-, p or n), but is neutral, and either massless or having an extremely small mass (compared to the mass of electron) and which interacts very weakly with matter. The correct decay process of neutron is : $n \rightarrow p + e^- + \nu$]

APPENDIX 6.1 : POWER CONSUMPTION IN WALKING

The table below lists the approximate power expended by an adult human of mass 60 kg.

Table 6.4 Approximate power consumption

Activity	Power (W)
Sleeping	75
Slow Walking	200
Bicycling	500
Heart beat	1.2

Mechanical work must not be confused with the everyday usage of the term work. A woman standing with a very heavy load on her head may get very tired. But no mechanical work is involved. That is not to say that mechanical work cannot be estimated in ordinary human activity.

Consider a person walking with constant speed v_0. The mechanical work he does may be estimated simply with the help of the work-energy theorem. Assume :

(a) The major work done in walking is due to the acceleration and deceleration of the legs with each stride (See Fig. 6.20).
(b) Neglect air resistance.
(c) Neglect the small work done in lifting the legs against gravity.
(d) Neglect the swinging of hands etc. as is common in walking.

As we can see in Fig. 6.20, in each stride the leg is brought from rest to a speed, approximately equal to the speed of walking, and then brought to rest again.

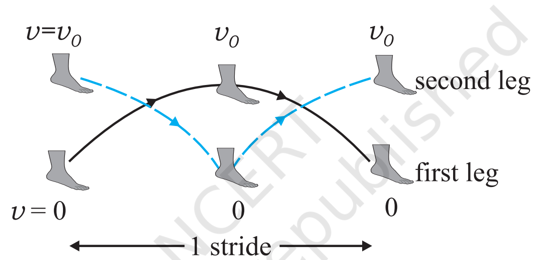

Fig. 6.20 *An illustration of a single stride in walking. While the first leg is maximally off the round, the second leg is on the ground and vice-versa*

The work done by one leg in each stride is $m_l v_0^2$ by the work-energy theorem. Here m_l is the mass of the leg.

Note $m_l v_0^2/2$ energy is expended by one set of leg muscles to bring the foot from rest to speed v_0 while an additional $m_l v_0^2/2$ is expended by a complementary set of leg muscles to bring the foot to rest from speed v_0. Hence work done by both legs in one stride is (study Fig. 6.20 carefully)

$$W_s = 2 m_l v_0^2 \tag{6.34}$$

Assuming mass of the leg m_l = 10 kg and slow running with a speed of 10 km in a hour which translates to approximately 3 m s^{-1}, we obtain

$$W_s = 180 \text{ J / stride}$$

If we take a stride to be 2 m long, the person covers 1.5 strides per second at his speed of 3 m s^{-1}. Thus the power expended

$$P = 180 \frac{\text{J}}{\text{stride}} \times 1.5 \frac{\text{stride}}{\text{second}}$$

$$= 270 \text{ W}$$

We must bear in mind that this is a lower estimate since several avenues of power loss (e.g. swinging of hands, air resistance etc.) have been ignored. The interesting point is that we did not worry about the forces involved. The forces, mainly friction and those exerted on the leg by the muscles of the rest of the body, are hard to estimate. Static friction does no work and we bypassed the impossible task of estimating the work done by the muscles by taking recourse to the work-energy theorem. We can also see the advantage of a wheel. The wheel permits smooth locomotion without the continual starting and stopping in mammalian locomotion.