2. **(a)** The chicken does positive work on the ground. **(b)** No work is done. **(c)** The crane does positive work on the bucket. **(d)** The force of gravity does negative work on the bucket. **(e)** The leg muscles do negative work on the individual.

4. **(a)** Kinetic energy is always positive. Mass and speed squared are both positive. **(b)** Gravitational potential energy can be negative when the object is lower than the chosen reference level.

6. The total energy of the bowling ball is conserved. Because the ball initially has gravitational potential energy mgh and no kinetic energy, it will again have zero kinetic energy when it returns to its original position. Air resistance and friction at the support will cause the ball to come back to a point slightly below its initial position. On the other hand, if anyone gives a forward push to the ball anywhere along its path, the demonstrator will have to duck.

8. **(a)** The effects are the same except for such features as having to overcome air resistance outside. **(b)** The person must lift his body slightly with each step on the tilted treadmill. Thus, the effect is that of running uphill.

10. The kinetic energy is converted to internal energy within the brake pads of the car, the roadway, and the tires.

12. Work is actually performed by the thigh bone (the femur) on the hips as the torso moves upwards a distance h. The force on the torso $\vec{\mathbf{F}}_{torso}$ is approximately the same as the normal force (since the legs are relatively light and are not moving
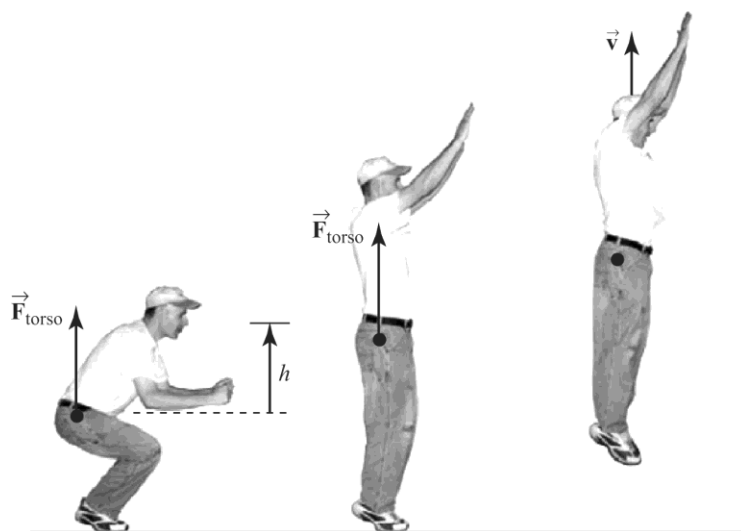
much), and the work done by

$\vec{F}_{torso}$

minus the work done by gravity

is equal

to the change in kinetic energy of

the

torso.

At full extension the torso

would

continue upwards, leaving the

legs

behind on the ground (!), except

that

the torso now does work on the

legs,

increasing their speed (and

decreasing

the torso speed) so that both

move

upwards together.

Note: An alternative way to think about problems that involve internal motions of an object is to note that the net work done on an object is equal to the net force times the displacement of the center of mass. Using this idea, the effect of throwing the arms upwards during the extension phase is accounted for by noting that the position of the center of mass is higher on the body with the arms extended, so that total displacement of the center of mass is greater.

14. If a crate is located on the bed of a truck, and the truck accelerates, the friction force exerted on the crate causes it to undergo the same acceleration as the truck, assuming that the crate doesn't slip. Another example is a car that accelerates because of the frictional forces between the road surface and its tires. This force is in the direction of the motion of the car and produces an increase in the car's kinetic energy.