a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics
Energy: Work

Science and Mathematics
Education Research Group

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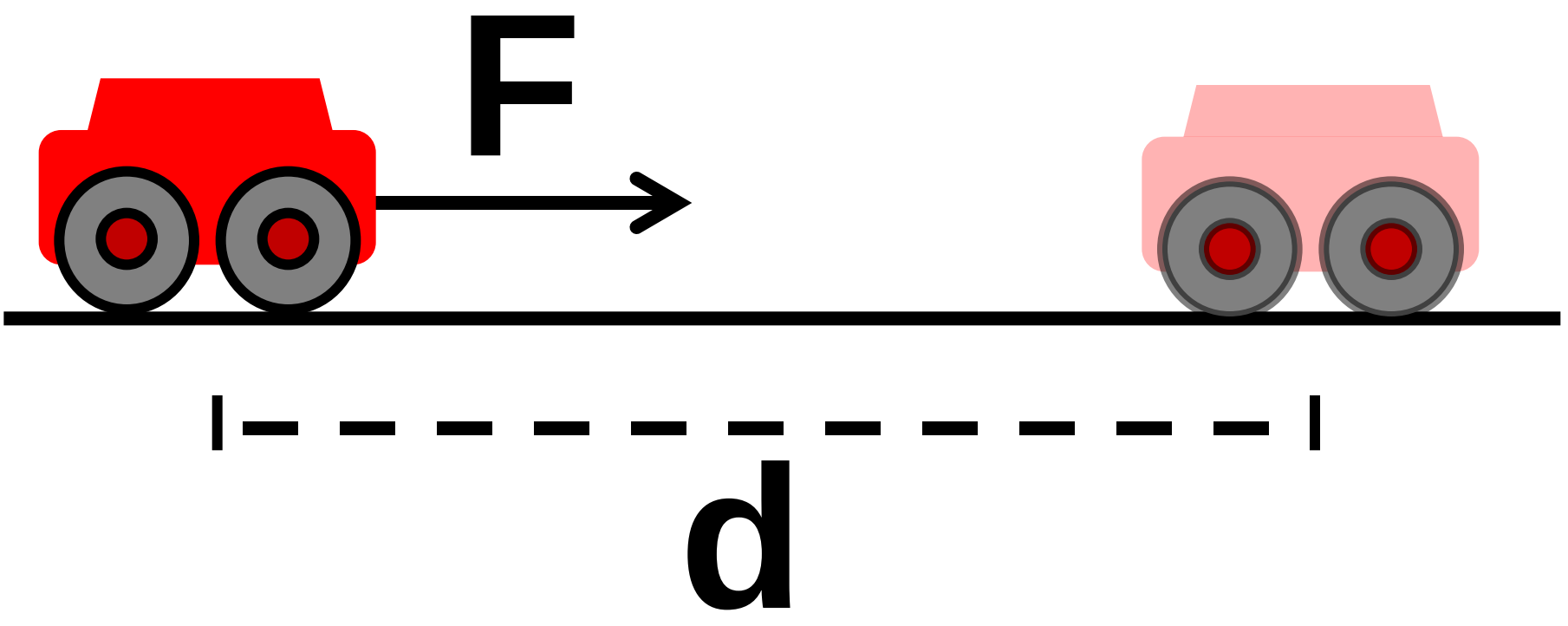
How Does “Work” Work?



Most Work Done I

Which of the following is the same unit as a joule (J)?

A. $\frac{\text{kg} \cdot \text{m}^2}{\text{s}}$

B. $\frac{\text{kg} \cdot \text{m}}{\text{s}^2}$

C. $\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$

D. $\frac{\text{N} \cdot \text{m}}{\text{s}^2}$

E. $\frac{\text{N} \cdot \text{m}^2}{\text{s}^2}$

Solution

Answer: C

Justification: From the formula for work, W = Fd, the unit for energy should be J = Nm.

The Newton is a unit of force, which can also be expressed using Newton's second law: $\sum \vec{F} = m\vec{a}$ as $N = kg\,\frac{m}{s^2}$.

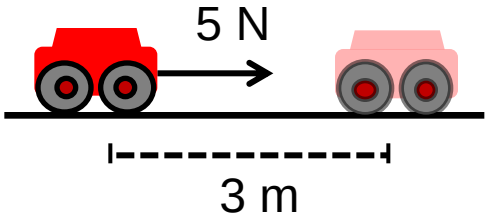
Therefore:

$$\mathrm{J} = \mathrm{N} \cdot \mathrm{m} = \frac{\mathrm{kg} \cdot \mathrm{m}}{\mathrm{s}^2} \cdot \mathrm{m} = \frac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^2}$$

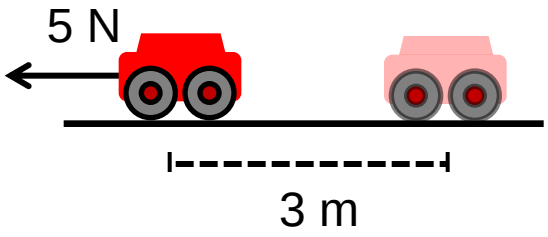
Most Work Done II

A 10 kg cart is moved 3 m to the right on a low-friction surface while you apply a 5 N force as shown. In which scenario do you do the most work? (Positive work is greater than negative work)

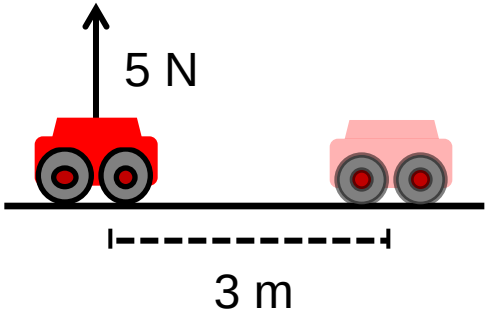
A.



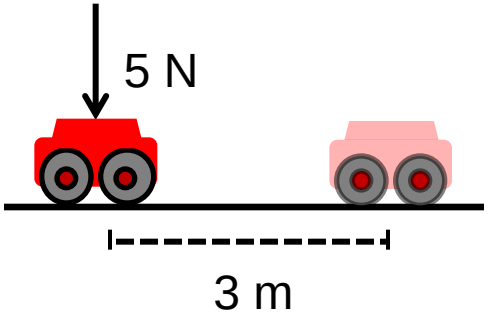
B.



C.



D.



E. $W_A = W_B = W_C = W_D$

Solution

Answer: A

Justification: Work depends on the magnitude of the force in the direction of the distance travelled.

In scenario A, **F** acts in the direction of the displacement, speeding the cart up and doing positive work.

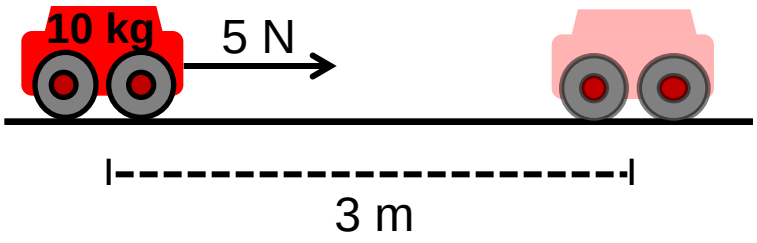
In scenario B, **F** acts in the opposite direction of the displacement, slowing the cart down and doing negative work.

In scenario C and D, **F** does not act in the direction of the displacement, thus there is no work done. The block is moving at constant speed.

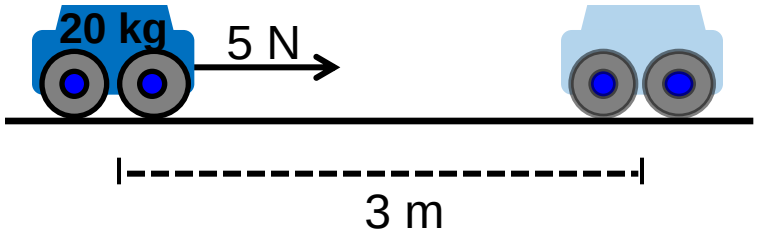
Most Work Done III

A 10 kg cart and a 20 kg cart start from rest on a low-friction surface. Each cart is pulled to the right with an external net force of 5 N over 3 m. On which cart is the most work done?

A. The 10 kg cart



B. The 20 kg cart



C. The work done is the same for both carts

Solution

Answer: C

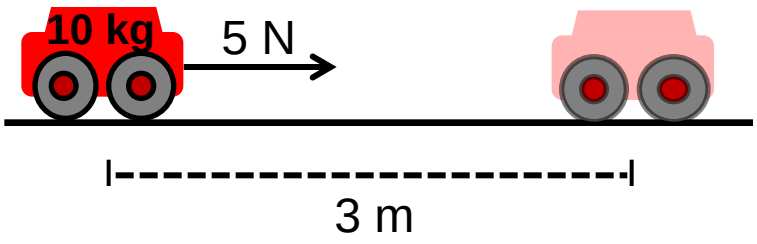
Justification: Both carts move a distance of 3 m to the right. Both carts experience a net force of 5 N to the right. Therefore, the work done must be W = 3 m x 5 N = 15 J for both carts.

Notice that the mass of the object does not appear in the formula used to calculate work, and thus has no impact on the amount of work done on an object.

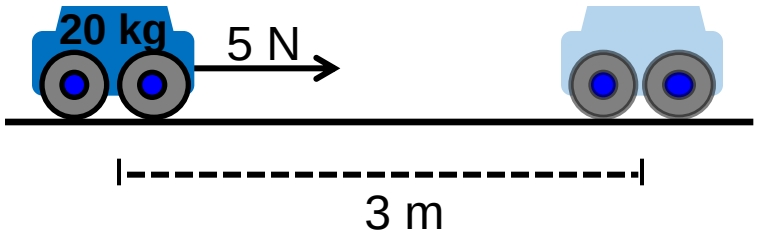
Most Work Done IV

A 10 kg cart and a 20 kg cart start from rest on a low-friction surface. Each cart is pulled to the right with an external net force of 5 N over 3 m. Which cart gains the most kinetic energy?

A. The 10 kg cart



B. The 20 kg cart



C. Both carts gain the same amount of kinetic energy

Solution

Answer: C

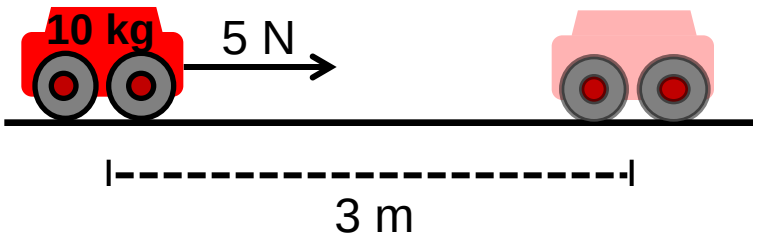
Justification: Both carts start at rest, with zero kinetic energy. The same force is applied, and the same amount of work is done on each cart.

This means that they gain the same amount of kinetic energy, so they must have the same amount of kinetic energy at the end.

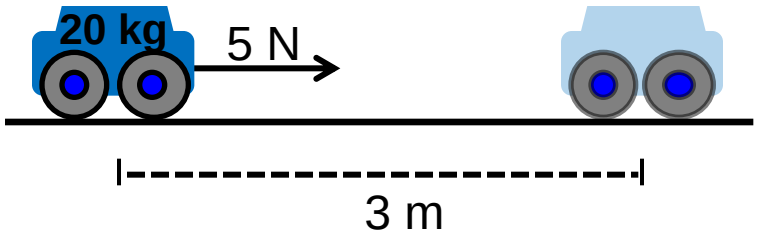
Most Work Done V

A 10 kg cart and a 20 kg cart start from rest on a frictionless surface. Each cart is pushed to the right with an external net force of 5 N over 3 m. Which cart has the greatest final speed after moving 3 m?

A. The 10 kg cart



B. The 20 kg cart



C. Both carts have the same final speed

Solution

Answer: A

Justification: Both carts start from rest and therefore have no initial kinetic energy. Since 15 J of work is done on each cart, they have 15 J of final kinetic energy.

10 kg cart:

$$W_{net} = \Delta E_K$$

$$15\ \text{J} = \frac{1}{2}(10\ \text{kg})v^2$$

$$v = \sqrt{3}\ \text{m/s}$$

20 kg cart:

$$W_{net} = \Delta E_K$$

$$15\ \text{J} = \frac{1}{2}(20\ \text{kg})v^2$$

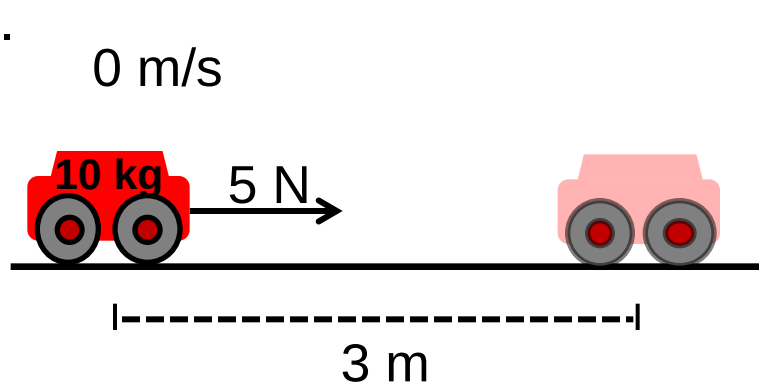
$$v = \sqrt{1.5}\ \text{m/s}$$

The 10 kg cart has a greater final speed. Notice, the ratio of final speeds is: $\frac{m_1 v_1^2}{2} = \frac{m_2 v_2^2}{2} \Rightarrow \frac{v_2}{v_1} = \sqrt{\frac{m_1}{m_2}} = \sqrt{2}$

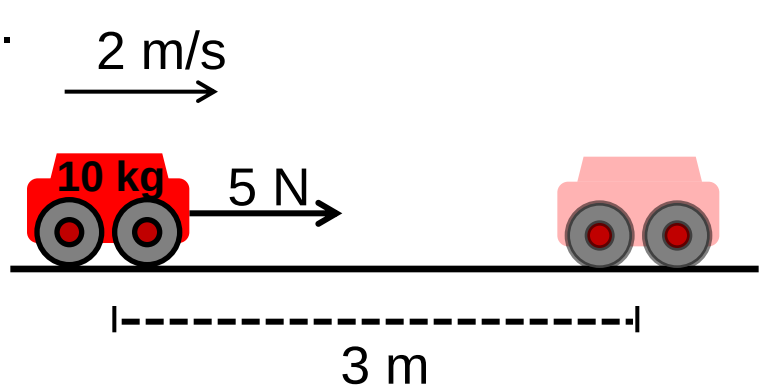
Most Work Done VI

Two 10 kg carts are pushed along a low friction table with a net force of 5 N over 3 m. One 10 kg cart starts from rest while the other has an initial speed of 2 m/s. On which cart is the most work being done after the carts move 3 m?

A.



B.



C. The work done on both carts is the same

Solution

Answer: C

Justification: Both carts move a distance of 3 m to the right. Both carts experience a net force of 5 N to the right. Therefore the work done must be W_{net} = 3 m x 5 N = 15 J for both carts.

Even though the force is applied for a shorter amount of time on the 2 m/s cart (since it will move 3 m faster), the work done is still the same.