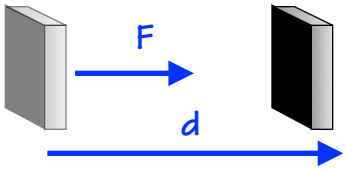
PhyzSpringboard: Introduction to Work

Work is a means by which energy can enter or leave an object or system. When positive work is done on an object, the object gains energy. When negative work is done on an object, the object loses energy. When the work done on an object is zero, the object's energy is left unchanged.

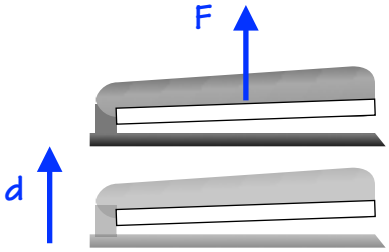
When work is done on an object, a force is applied to the object and the object undergoes a displacement. A relationship exists between the type of work done on an object and the relative directions of force and displacement during the interaction. Consider each situation below. Draw the force and displacement vectors in each case and determine whether positive, negative, or no work is done. (Remember to justify your conclusion in terms of energy gain or loss.)

1. Throwing an eraser.



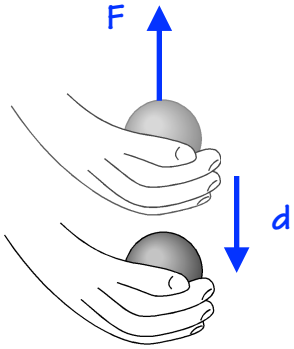
Energy is gained.
F ∥ d ⇒ W is +

2. Lifting a stapler.



Energy is gained.
F ∥ d ⇒ W is +

3. Catching a falling ball.



Energy is lost.
F ↑↓ d ⇒ W is –

4. Lowering a chair from table height to the floor.
(You draw it!)

Energy is lost.
F ↑↓ d ⇒ W is –

What correlation—if any—is apparent between the sign of the work done and the relative directions of force and displacement?

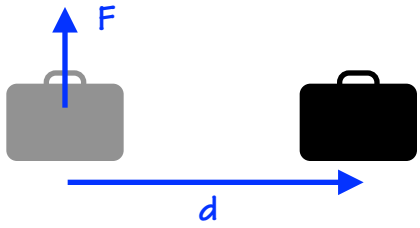
The work done on an object is positive when — force and displacement are in the same direction (parallel).

The work done on an object is negative when — force and displacement are opposite (antiparallel).

5. Carrying a briefcase across the room.

Energy is neither gained nor lost.

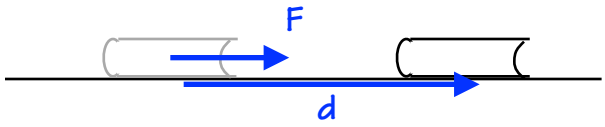
F ⊥ d ⇒ W is 0



6. Pushing a book across a table.

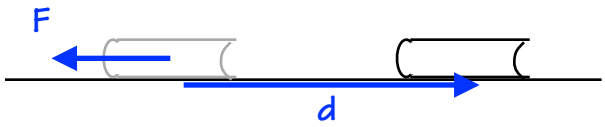
a. What kind of work does the "pusher" do?

Person pushing: F ll d ⇒ W is +



b. What else is going on here?

Friction: F ↑↓ d ⇒ W is –



7. Consider a stationary sled with two ropes attached—one to the front and one to the rear.

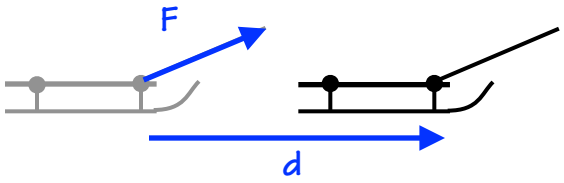
a. If the front rope is pulled forward, the sled speeds up.

i. The sled √ gains energy __loses energy.

ii. The work done is √ positive __negative __zero.

iii. The force and displacement vectors are __parallel __antiparallel __perpendicular √ something else.

Acute



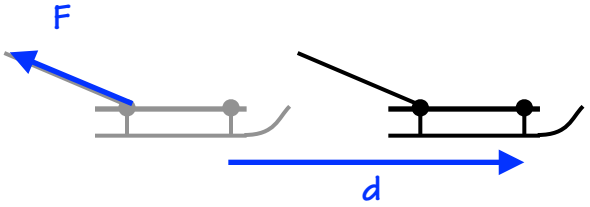
b. If the sled is moving and the rear rope is pulled backward, the sled slows down.

i. The sled __gains energy √ loses energy.

ii. The work done is __positive √ negative __zero.

iii. The force and displacement vectors are __parallel __antiparallel __perpendicular √ something else.

Obtuse



Do these new findings agree with the conclusion drawn after exercise 4? If not, what modifications are called for?

No. Work is positive also when the angle between F and d is acute and negative when t angle is obtuse.

The angle between the force and displacement vectors is given the symbol ϕ. Restate the conclusions above in terms of ranges of the angle ϕ.

W > 0 when 0 ≤ ϕ <90*

W < 0 when 90° < ϕ ≤ 180°

W = 0 when ϕ = 90°