

ENERGY

Energy is a scalar

Energy is conserved

- Cannot be created or destroyed, just shuffled around

Unit for energy is a joule (J)

- $1 \text{ J} = 1 \text{ Nm}$

WORK

In physics, work (symbol W) is the energy needed to enact a force through some displacement

More of a pain to walk to the 2nd floor than the 3rd floor

$$W = F_{||} D$$

Only the force parallel to displacement does work

$$W = Fd\cos\theta$$

I.e. You apply 50 N of force horizontally as you move a grocery cart 30 m

- $W = 50 \text{ N} \times 30 \text{ m} = 1500 \text{ J}$

Assume force is *constant*

A force can be exerted on an object and do no work



WHICH OF THESE DOES WORK?

- A. Holding a bag of groceries
- B. A large asteroid drifts 20 km at a constant speed
- C. Lifting a mug of hot chocolate to your mouth
- D. Gravity on a couch as you push it across the room

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BE SPECIFIC!

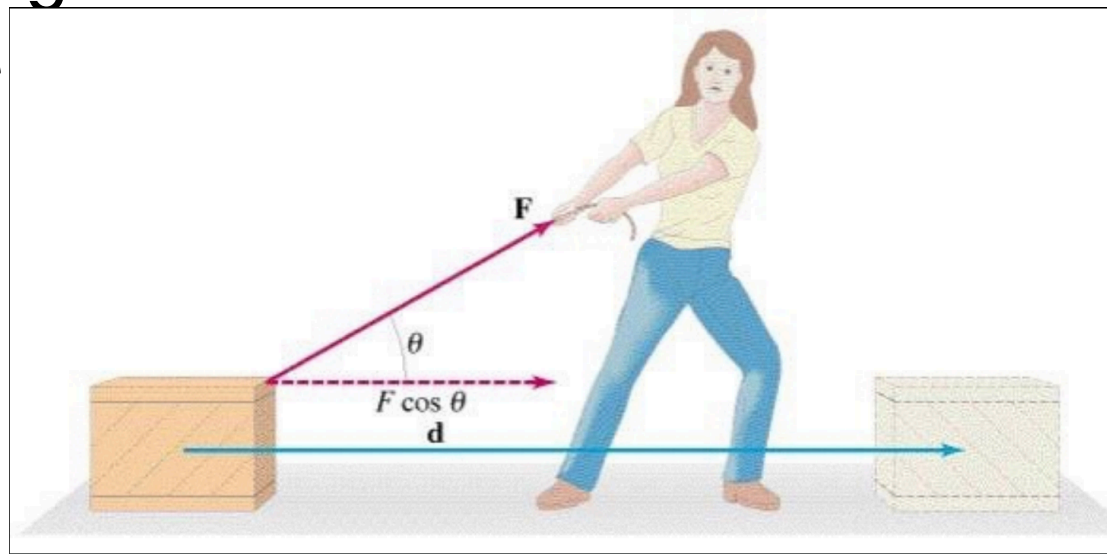
Is work done *by* an object or work done *on* an object?

Is the work done by a *particular force* or work done by the *net force*?

You're off to college, and you want to take your entire manga collection.

You drag the 50 kg crate 40 m across the quad of your new campus, applying a constant applied force $F_{\text{app}} = 100\text{N}$ at an angle of 37° from the horizontal. The ground exerts a friction force $f = 50\text{N}$.

- Determine the work done by each force acting on the crate and the net work done on the crate.
- $W_g = 0,$
- $W_n = 0,$
- $W_{\text{app}} = 100\text{N} \cos 37^\circ \times 40\text{m} = 3200\text{J}$
- $W_{\text{fr}} = -50\text{N} \times 40\text{m} = -2000\text{J}$
- $W_{\text{net}} = 1200\text{J}$



NEGATIVE ENERGY

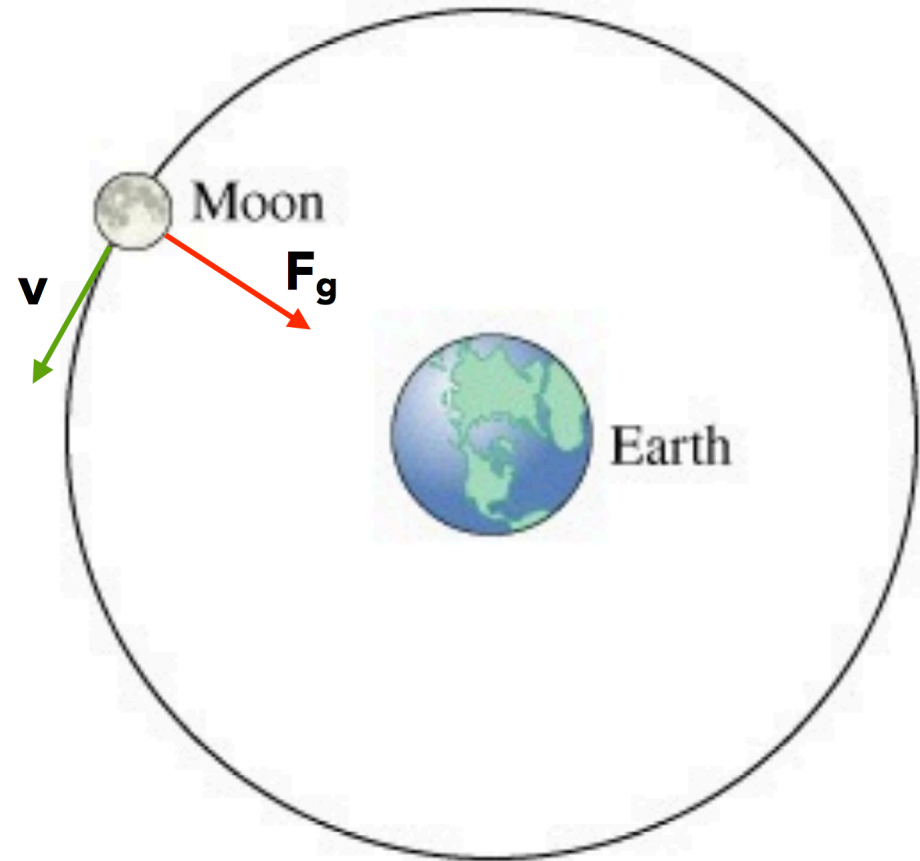
Wait, why is friction's work negative?

Forces against motion do negative work

Energy put into the system is positive, energy taken out of the system is negative

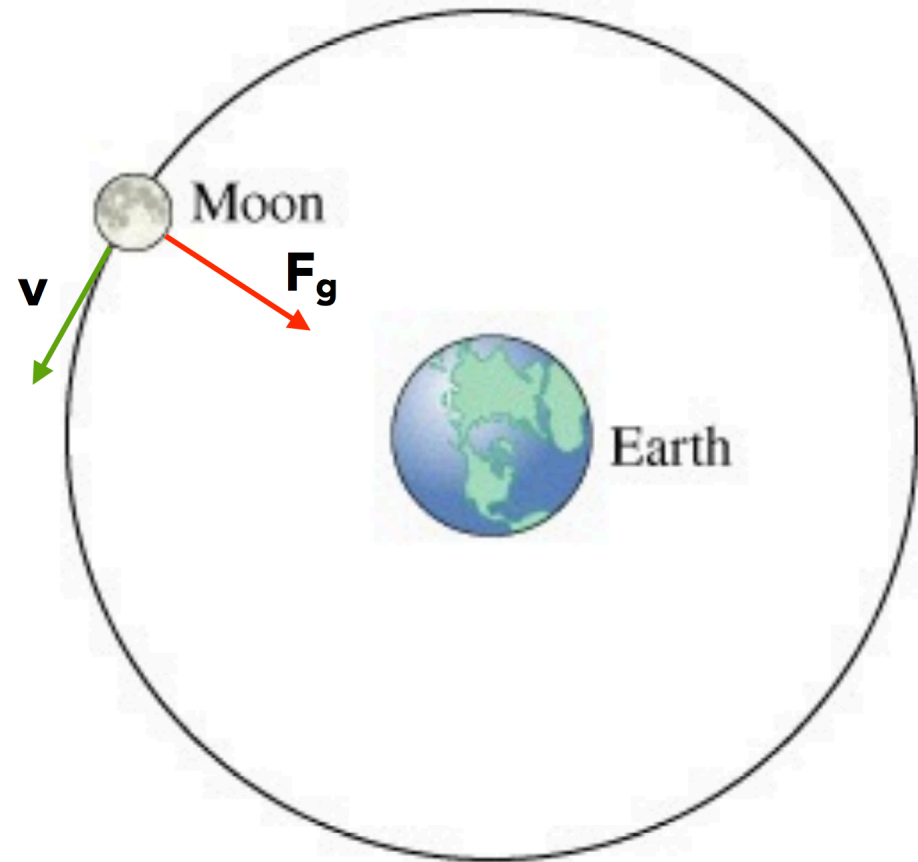
THE MOON REVOLVES AROUND THE EARTH IN A CIRCULAR ORBIT, KEPT THERE BY THE GRAVITATIONAL FORCE EXERTED BY THE EARTH. WHAT WORK DOES GRAVITY DO ON THE MOON?

- A. Positive work
- B. Negative work
- C. No work at all



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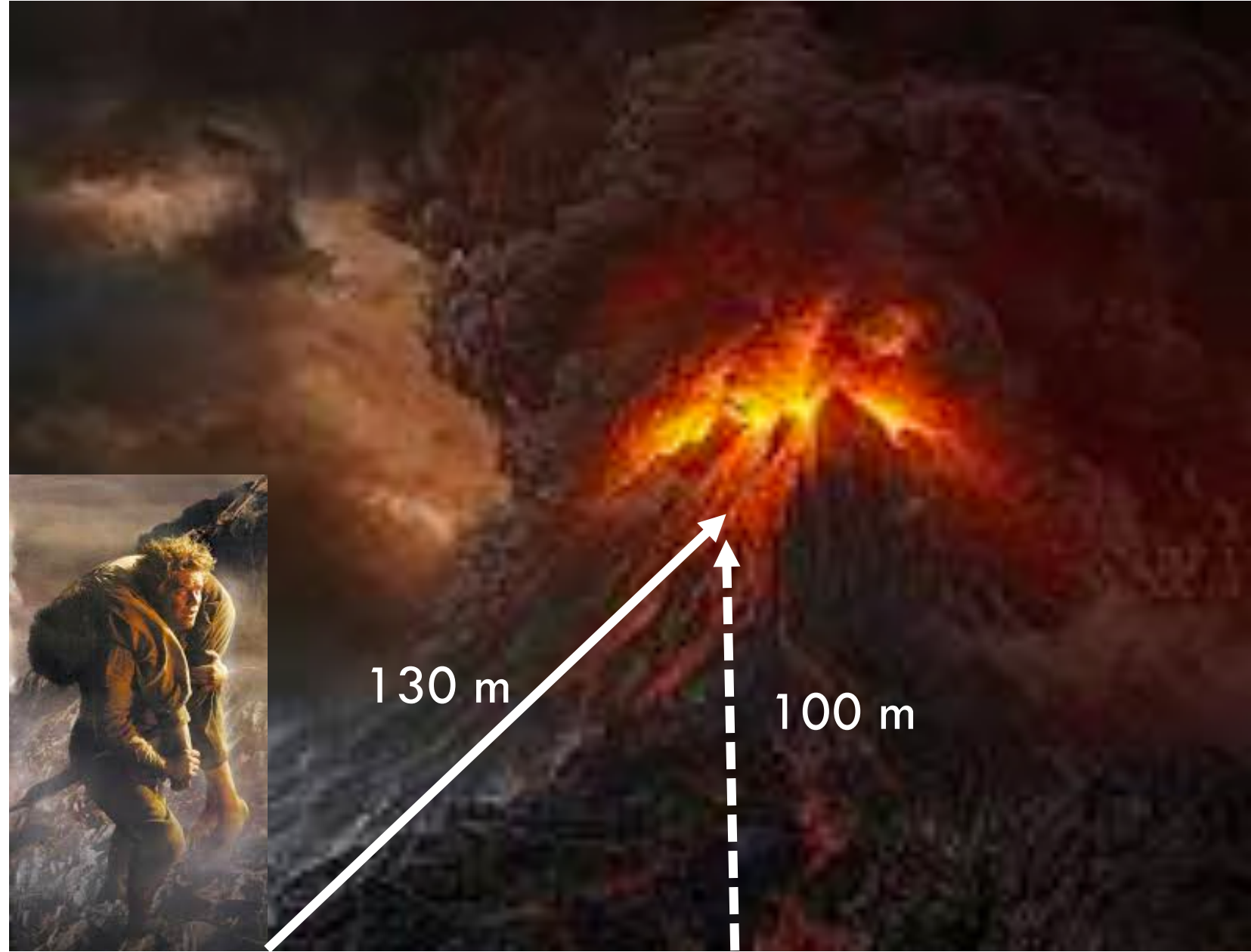
How much work does Sam do on Frodo (mass 50 kg) to carry him up the 100 m tall slope of Mt. Doom, over a total distance of 130 m?

$$W_{\text{sam}} = 50 \text{ kg} \times 9.8 \text{ m/s}^2 \times 100 \text{ m} = 49,000 \text{ J}$$

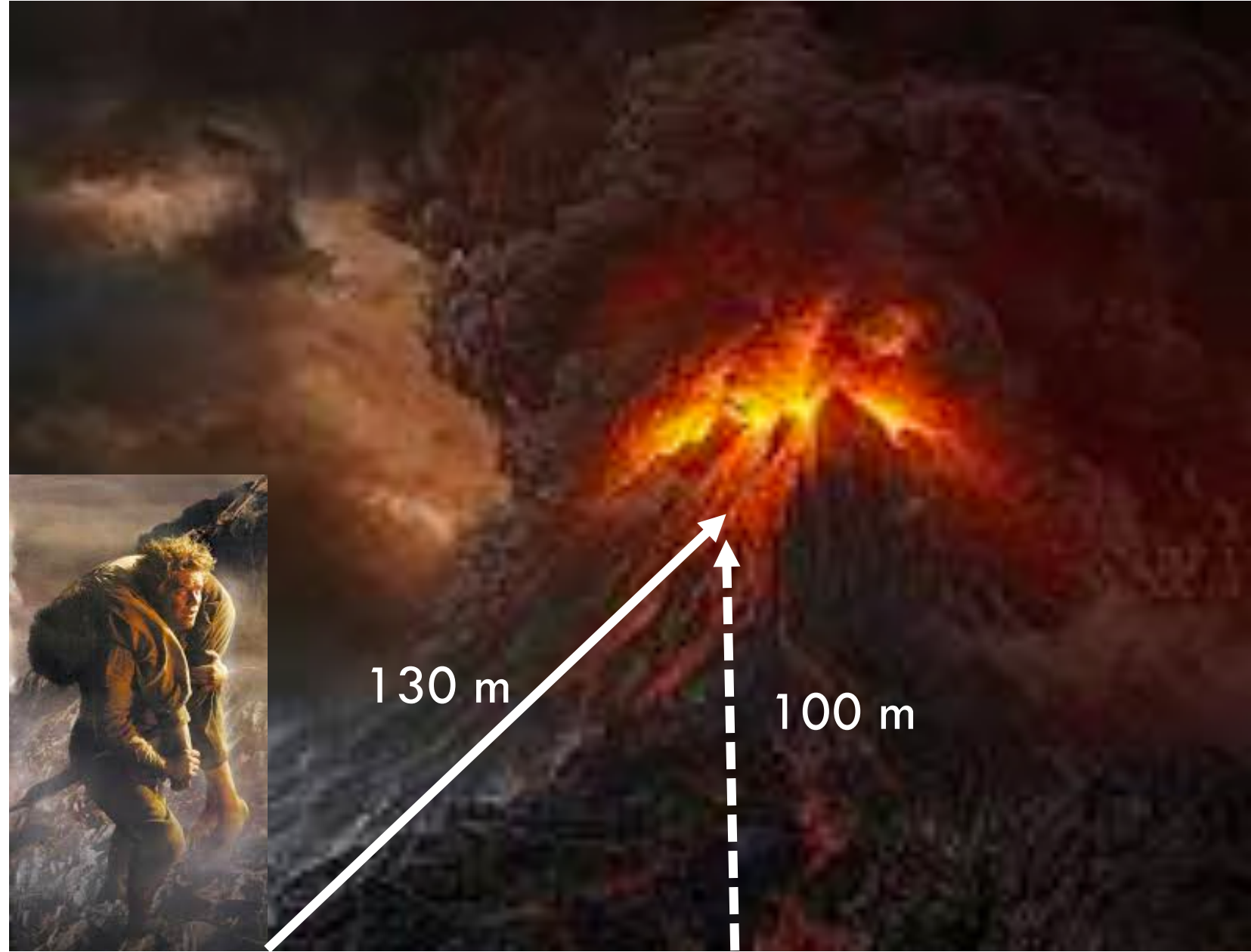


How much work does gravity do on Frodo?

$$W_G = -(50 \text{ kg} \times 9.8 \text{ m/s}^2) \times 100 \text{ m} \\ = -49,000 \text{ J}$$



What is the net
work done on
Frodo?
0 J



WORK AND VARYING FORCES

I.e. Spring when stretched or compressed

For unevenly applied forces, can use graph to find work!



FORCE VS. DISPLACEMENT GRAPHS

3RD WAY TO CALCULATE WORK

You decelerate your car of mass 1000 kg from a velocity of 30 m/s to 10 m/s.

What is the work done on the car by the brakes?

$$W = \Delta KE$$

KINETIC ENERGY (KE)

Energy is the ability to do work

A bowling ball exerts a force on a pin and moves it a distance

- The bowling ball did work, thus has energy
- Kinetic energy is **energy of motion**

$$KE = \frac{1}{2} m v^2$$

Translational kinetic energy

- "Translational" distinguishes from "rotational"



WORK - ENERGY THEOREM

Net work is equal to the change in kinetic energy

You decelerate your car of mass 1000 kg from a velocity of 30 m/s to 10 m/s.

What is the net work done on the car?

$$W_{\text{net}} = \Delta KE$$

$$W_{\text{net}} = \frac{1}{2} mv_f^2 - \frac{1}{2} mv_i^2$$

$$W_{\text{net}} = (1/2) \times 1000\text{kg} \times (10\text{m/s})^2 - (1/2) \times 1000\text{kg} \times (30\text{m/s})^2$$

$$W_{\text{net}} = -4 \times 10^5 \text{ J}$$

AN OBJECT INITIALLY HAS ENERGY KE. IF ITS MASS IS HALVED, WHAT HAPPENS TO ITS KINETIC ENERGY?

- A. Halved
- B. Quartered
- C. Stays the same
- D. Doubled
- E. Quadrupled

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AN OBJECT INITIALLY HAS ENERGY KE. IF ITS VELOCITY IS DOUBLED, WHAT HAPPENS TO ITS KINETIC ENERGY?

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