

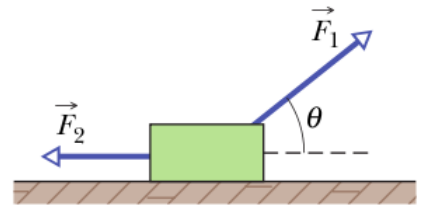
# PHYSICS – problem solving exercises

## 4. Dynamics: force, work, energy, power

**Notes:** air friction is neglected in all cases, magnitude of free fall acceleration is  $10 \text{ m/s}^2$

### **Problem 1:**

Forces  $F_1$  and  $F_2$  are applied to a lunchbox as it slides at constant velocity over a frictionless floor. We are to decrease angle  $\theta$  without changing the magnitude of  $F_1$ . For constant velocity, should we increase, decrease, or maintain the magnitude of  $F_2$ ?



### **Problem 2:**

A vertical force  $F$  is applied to a block of mass  $m$  that lies on a floor. What happens to the magnitude of the normal force  $F_N$  on the block from the floor as magnitude  $F$  is increased from zero if force  $F$  is (a) downward and (b) upward?

### **Problem 3:**

A net force  $F = 120 \text{ N}$  acts on an object. The object accelerates at a constant rate and travels a distance of  $650 \text{ m}$  (from rest) in  $14 \text{ s}$ . What is the object's mass?

**Problem 4:**

Who does a bigger work during movement of a 5 kg book from ground to a bookshelf at 2 m: Petr, who vertically lifts the book from ground, or Josef, who pushes the book along a 7 m long inclined plane?

**Problem 5:**

Petr from Problem 4 shifts the book in 2 s, while Josef shifts it in 8 s. What are Petr's and Josef's powers?

**Problem 6:**

A machine of 250 W is moving with a piston which can move to a distance of 10 cm in 1 s. What is a force exerted on the piston?

**Problem 7:**

A machine is moving with a piston to a distance of 5 cm in 2 s. What is a power of the machine if the force exerted on the piston is the same as in Problem 6?

**Problem 8:**

A man pulls a box of mass 75 kg applying a force 220 N , directed at an angle  $45^\circ$  above the horizontal direction. (a) How much work is done by the man during the box's displacement to a distance of 10 m?  
(b) How much work is done by the gravitational force?

**Problem 9:**

A car of mass 2000 kg is moving along a highway at 36 km/h. What is a speed of a motorbike of mass 300 kg if the car's and motorbike's kinetic energies are the same?

**Problem 10:**

A 2 kg body is freely falling from a height of 40 m. (a) What is its impact speed if we neglect air resistance?  
(b) How does change its impact speed if air resistance is taken into consideration?

**Problem 11:**

What is elastic potential energy of a spring with a spring constant of 4500 N/m when compressed by 12 cm?

**Problem 12:**

A cyclist travels at a constant velocity and exerts a force balancing the air resistance force of 15.0 N.

(a) How much work does he do while riding 251 m?

(b) What power does he develop if he travels this distance in 30.0 s?

**Problem 13:**

A 80.0 kg man reached the seventh floor which is 24 m above a ground level using the stairs in 7 minutes.

What is his mean power? How much work must he do?

**Problem 14:**

A 1.5 tons helicopter with an upward thrust of its motors of 20 kN uniformly accelerates in vertical direction and moves to the height of 500 m in 80 s. What is a power of its motors?

**Problem 15:**

How much work is done by all acting forces (including also the net force) during movement of the 1.5 tons helicopter from a ground level to a height of 500 m if:

- (a) the helicopter accelerates in vertical direction and the upward thrust of its motors is 20 kN?
- (b) the helicopter moves in vertical direction with a constant speed of 10 m/s?

**Problem 16:**

A 300 kg sledge moves on a rough surface (i.e. there is a friction force) with a constant velocity of 20 m/s. Its power is 0.4 MW. What is the magnitude of the force which must be exerted by its motors?

**Problem 17:**

How much work is done by gravitational force on a book of  $m = 2.0$  kg, when:

- (a) the book is moved upward to a height of 2.0 m
- (b) the book is held at the height of 2.0 m
- (c) the book is moved horizontally to a distance of 2.0 m.

**Problem 18:**

A helicopter lifts a 72 kg astronaut 15 m vertically from the ocean by means of a cable. The acceleration of the astronaut is  $g/10$ . How much work is done on the astronaut by (a) the force from the helicopter (b) the gravitational force on her? Just before she reaches the helicopter, what are her (c) kinetic energy and (d) speed?

**Problem 19:**

If a rocket with an Apollo spacecraft attached has a combined mass of  $2.9 \times 10^5$  kg and reached a speed of 11.2 km/s, how much kinetic energy would it then have?

**Problem 20:**

What is the spring constant of a spring that stores 25 J of elastic potential energy when compressed by 7.5 cm?

**Problem 21:**

A small, initially stationary block is released on a frictionless ramp at a height of 3.0 m. Hill heights along the ramp are as shown. The hills have identical circular tops, and the block does not fly off any hill.

- (a) Which hill is the first the block cannot cross?  
(b) On which hilltop is the centripetal acceleration of the block greatest?

