what value of the angle α will the time of sliding be the least? What will it be equal to?

•• **1.67.** A bar of mass m is pulled by means of a thread up an inclined plane forming an angle α with the horizontal (Fig. 1.13). The coefficient of friction is equal to k. Find the angle β which the thread must form with the inclined plane for the tension of the thread to be minimum. What is it equal to?

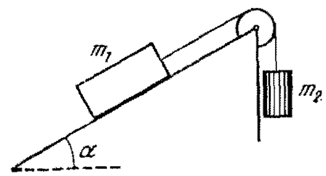

Fig. 1.11.

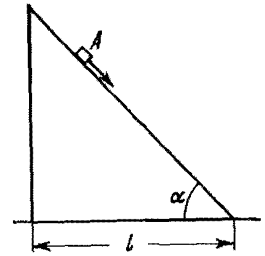

Fig. 1.12.

•• **1.68.** At the moment $t = 0$ the force $F = at$ is applied to a small body of mass m resting on a smooth horizontal plane (a is a constant). The permanent direction of this force forms an angle α with the horizontal (Fig. 1.14). Find:

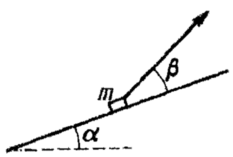

Fig. 1.13.

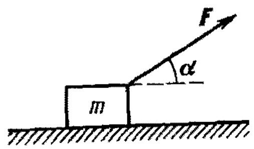

Fig. 1.14.

(a) the velocity of the body at the moment of its breaking off the plane;

(b) the distance traversed by the body up to this moment.

•• **1.69.** A bar of mass m resting on a smooth horizontal plane starts moving due to the force $F = mg/3$ of constant magnitude. In the process of its rectilinear motion the angle α between the direction of this force and the horizontal varies as $\alpha = as$, where a is a constant, and s is the distance traversed by the bar from its initial position. Find the velocity of the bar as a function of the angle α.

•• **1.70.** A horizontal plane with the coefficient of friction k supports two bodies: a bar and an electric motor with a battery on a block. A thread attached to the bar is wound on the shaft of the electric motor. The distance between the bar and the electric motor is equal to l. When the motor is switched on, the bar, whose mass is twice as great as that of the other body, starts moving with a constant acceleration w. How soon will the bodies collide?

••• **1.71.** A pulley fixed to the ceiling of an elevator car carries a thread whose ends are attached to the loads of masses m_1 and m_2. The car starts going up with an acceleration $\mathbf{w}_0$. Assuming the masses of the pulley and the thread, as well as the friction, to be negligible find:

(a) the acceleration of the load m_1 relative to the elevator shaft and relative to the car;

(b) the force exerted by the pulley on the ceiling of the car.

•• **1.72.** Find the acceleration $\mathbf{w}$ of body 2 in the arrangement shown in Fig. 1.15, if its mass is η times as great as the mass of bar 1 and the angle that the inclined plane forms with the horizontal is equal to α. The masses of the pulleys and the threads, as well as the friction, are assumed to be negligible. Look into possible cases.

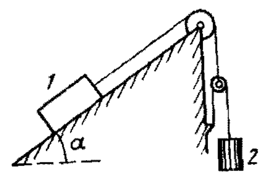

Fig. 1.15.

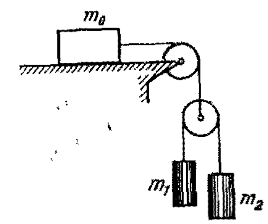

Fig. 1.16.

•• **1.73.** In the arrangement shown in Fig. 1.16 the bodies have masses m_0, m_1, m_2, the friction is absent, the masses of the pulleys and the threads are negligible. Find the acceleration of the body m_1. Look into possible cases.

•• **1.74.** In the arrangement shown in Fig. 1.17 the mass of the rod M exceeds the mass m of the ball. The ball has an opening permitting it to slide along the thread with some friction. The mass of the pulley and the friction in its axle are negligible. At the initial moment the ball was located opposite the lower end of the rod. When set free,

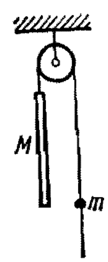

Fig. 1.17.

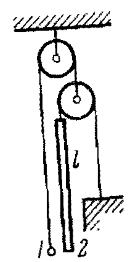

Fig. 1.18.

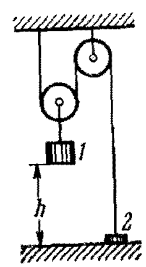

Fig. 1.19.

both bodies began moving with constant accelerations. Find the friction force between the ball and the thread if t seconds after the beginning of motion the ball got opposite the upper end of the rod. The rod length equals l.

•• **1.75.** In the arrangement shown in Fig. 1.18 the mass of ball *1* is $\eta = 1.8$ times as great as that of rod *2*. The length of the latter is $l = 100$ cm. The masses of the pulleys and the threads, as well as the friction, are negligible. The ball is set on the same level as the lower end of the rod and then released. How soon will the ball be opposite the upper end of the rod?

••• **1.76.** In the arrangement shown in Fig. 1.19 the mass of body *1* is $\eta = 4.0$ times as great as that of body *2*. The height $h = 20$ cm. The masses of the pulleys and the threads, as well as the friction, are negligible. At a certain moment body *2* is released and the arrangement set in motion. What is the maximum height that body *2* will go up to?

•• **1.77.** Find the accelerations of rod A and wedge B in the arrangement shown in Fig. 1.20 if the ratio of the mass of the wedge to that of the rod equals η, and the friction between all contact surfaces is negligible.

••• **1.78.** In the arrangement shown in Fig. 1.21 the masses of the wedge M and the body m are known. The appreciable friction exists

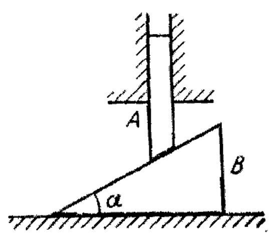

Fig. 1.20.

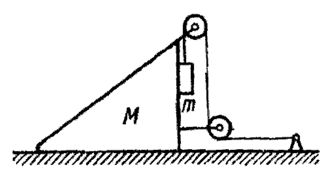

Fig. 1.21.

only between the wedge and the body m, the friction coefficient being equal to k. The masses of the pulley and the thread are negligible. Find the acceleration of the body m relative to the horizontal surface on which the wedge slides.

•• **1.79.** What is the minimum acceleration with which bar A (Fig. 1.22) should be shifted horizontally to keep bodies *1* and *2* stationary relative to the bar? The masses of the bodies are equal, and the coefficient of friction between the bar and the bodies is equal to k. The masses of the pulley and the threads are negligible, the friction in the pulley is absent.

•• **1.80.** Prism *1* with bar *2* of mass m placed on it gets a horizontal acceleration w directed to the left (Fig. 1.23). At what maximum value of this acceleration will the bar be still stationary relative to the prism, if the coefficient of friction between them $k < \cot \alpha$?

••• **1.81.** Prism *1* of mass m_1 and with angle α (see Fig. 1.23) rests on a horizontal surface. Bar *2* of mass m_2 is placed on the prism. Assuming the friction to be negligible, find the acceleration of the prism.

••• **1.82.** In the arrangement shown in Fig. 1.24 the masses m of the bar and M of the wedge, as well as the wedge angle α, are known.

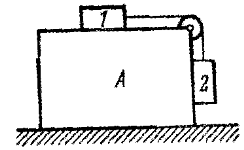

Fig. 1.22.

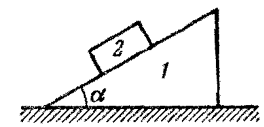

Fig. 1.23.

The masses of the pulley and the thread are negligible. The friction is absent. Find the acceleration of the wedge M.

••• **1.83.** A particle of mass m moves along a circle of radius R. Find the modulus of the average vector of the force acting on the particle over the distance equal to a quarter of the circle, if the particle moves

(a) uniformly with velocity v;

(b) with constant tangential acceleration w_τ, the initial velocity being equal to zero.

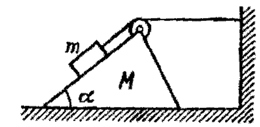

Fig. 1.24.

• **1.84.** An aircraft loops the loop of radius $R = 500$ m with a constant velocity $v = 360$ km per hour. Find the weight of the flyer of mass $m = 70$ kg in the lower, upper, and middle points of the loop.

••• **1.85.** A small sphere of mass m suspended by a thread is first taken aside so that the thread forms the right angle with the vertical and then released. Find:

(a) the total acceleration of the sphere and the thread tension as a function of θ, the angle of deflection of the thread from the vertical;

(b) the thread tension at the moment when the vertical component of the sphere's velocity is maximum;

(c) the angle θ between the thread and the vertical at the moment when the total acceleration vector of the sphere is directed horizontally.

•• **1.86.** A ball suspended by a thread swings in a vertical plane so that its acceleration values in the extreme and the lowest position are equal. Find the thread deflection angle in the extreme position.

••• **1.87.** A small body A starts sliding off the top of a smooth sphere of radius R. Find the angle θ (Fig. 1.25) corresponding to the point at which the body breaks off the sphere, as well as the break-off velocity of the body.

•• **1.88.** A device (Fig. 1.26) consists of a smooth L-shaped rod located in a horizontal plane and a sleeve A of mass m attached by a weight-