SELECTED PROBLEMS ABOUT THE WORK AND KINETIC ENERGY

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P1.

•8 A ice block floating in a river is pushed through a displacement $\vec{d} = (15\ \text{m})\hat{i} - (12\ \text{m})\hat{j}$ along a straight embankment by rushing water, which exerts a force $\vec{F} = (210\ \text{N})\hat{i} - (150\ \text{N})\hat{j}$ on the block. How much work does the force do on the block during the displacement?

Ans: 4950J

P2.

••15 GO Figure 7-28 shows three forces applied to a trunk that moves leftward by 3.00 m over a frictionless floor. The force magnitudes are $F_1 = 5.00$ N, $F_2 = 9.00$ N, and $F_3 = 3.00$ N, and the indicated angle is $\theta = 60.0°$. During the displacement, (a) what is the net work done on the trunk by the three forces and (b) does the kinetic energy of the trunk increase or decrease?

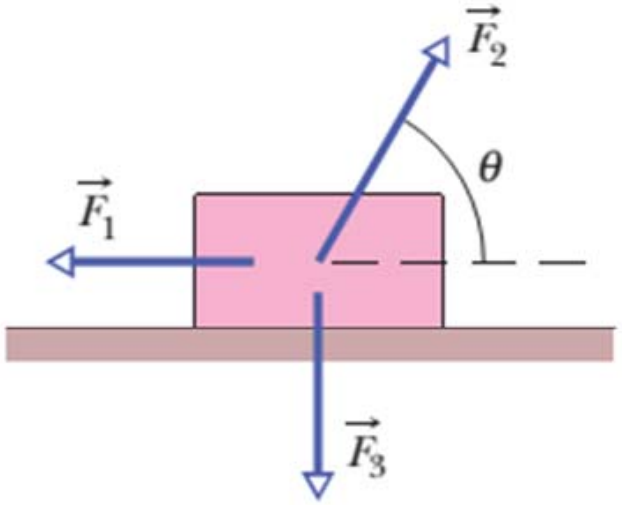


Figure 7-28 Problem 15.

Ans: a) 1.5J b) KE increases

P3.

••39 GO A force $\vec{F} = (cx - 3.00x^2)\hat{i}$ acts on a particle as the particle moves along an x axis, with $\vec{F}$ in newtons, x in meters, and c a constant. At $x = 0$, the particle's kinetic energy is 20.0 J; at $x = 3.00$ m, it is 11.0 J. Find c.

Ans: $c = 4$

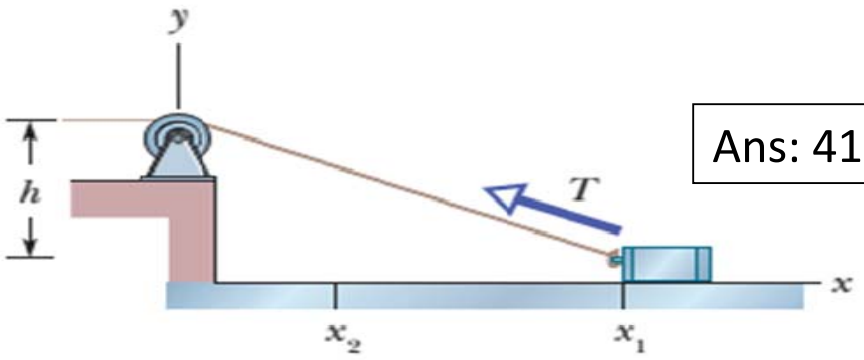
P4.

••38 A 1.5 kg block is initially at rest on a horizontal frictionless surface when a horizontal force along an x axis is applied to the block. The force is given by $\vec{F}(x) = (2.5 - x^2)\hat{i}$ N, where x is in meters and the initial position of the block is $x = 0$. (a) What is the kinetic energy of the block as it passes through $x = 2.0$ m? (b) What is the maximum kinetic energy of the block between $x = 0$ and $x = 2.0$ m?

Ans: a) 2.33J b) 2.635J

P5.

•••42 GO Figure 7-41 shows a cord attached to a cart that can slide along a frictionless horizontal rail aligned along an x axis. The left



Ans: 41.7J

end of the cord is pulled over a pulley, of negligible mass and friction and at cord height $h = 1.20$ m, so the cart slides from $x_1 = 3.00$ m to $x_2 = 1.00$ m. During the move, the tension in the cord is a constant 25.0 N. What is the change in the kinetic energy of the cart during the move?

According to the work-energy theorem, the change in the kinetic energy of an object is equal to the work done on the object. The definition of work yields

$\Delta K = W = \int T_x\, dx = \int [-Tx/\sqrt{(x^2 + h^2)}]dx$

Changing the variable from x to $s = \sqrt{(x^2 + h^2)}$ *and integrating from* x_1 *to* x_2 *, we get*

$\Delta K = -\int Tds = -T[\sqrt{(x_2^2 + h^2)} - \sqrt{(x_1^2 + h^2)}]$

POWER:

The time rate at which work is done by a force is said to be the **power**

$$1 \text{ watt} = 1 \text{ W} = 1 \text{ J/s} = 0.738 \text{ ft} \cdot \text{lb/s}$$

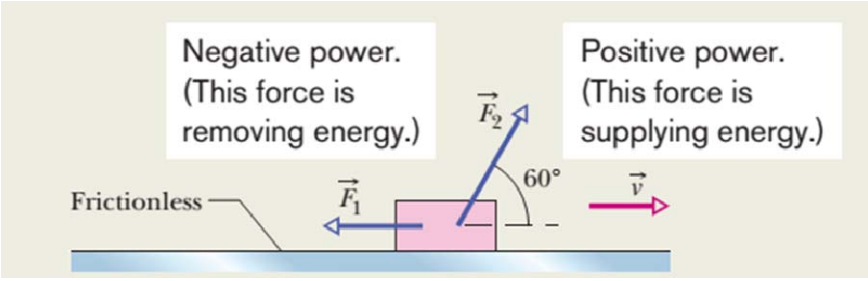
$$1 \text{ horsepower} = 1 \text{ hp} = 550 \text{ ft} \cdot \text{lb/s} = 746 \text{ W}.$$

$$P = \frac{dW}{dt} \qquad P = \vec{F} \cdot \vec{v} \quad \text{(instantaneous power).}$$

$$P_{avg} = \frac{W}{\Delta t}. \quad \textit{average power}$$

P6.

Here we calculate an instantaneous work—that is, the rate at which work is being done at any given instant rather than averaged over a time interval. Figure 7-15 shows constant forces $\vec{F}_1$ and $\vec{F}_2$ acting on a box as the box slides rightward across a frictionless floor. Force $\vec{F}_1$ is horizontal, with magnitude 2.0 N; force $\vec{F}_2$ is angled upward by 60° to the floor and has magnitude 4.0 N. The speed v of the box at a certain instant is 3.0 m/s. What is the power due to each force acting on the box at that instant, and what is the net power?



Ans: $P_{m\vec{g}} = P_{\vec{N}} = 0$

$P_{\vec{F}_1} = -6W$, $P_{\vec{F}_2} = 6W$

$P_{net} = 0$

P7.

•45 SSM ILW A 100 kg block is pulled at a constant speed of 5.0 m/s across a horizontal floor by an applied force of 122 N directed 37° above the horizontal. What is the rate at which the force does work on the block?

Ans: 488W

P8.

••47 A machine carries a 4.0 kg package from an initial position of $\vec{d}_i = (0.50\ \text{m})\hat{i} + (0.75\ \text{m})\hat{j} + (0.20\ \text{m})\hat{k}$ at $t = 0$ to a final position of $\vec{d}_f = (7.50\ \text{m})\hat{i} + (12.0\ \text{m})\hat{j} + (7.20\ \text{m})\hat{k}$ at $t = 12\ \text{s}$. The constant force applied by the machine on the package is $\vec{F} = (2.00\ \text{N})\hat{i} + (4.00\ \text{N})\hat{j} + (6.00\ \text{N})\hat{k}$. For that displacement, find (a) the work done on the package by the machine's force and (b) the average power of the machine's force on the package.

ANS: a) 101J and b) 8.42W

P9.

•46 The loaded cab of an elevator has a mass of 3.0×10^3 kg and moves 210 m up the shaft in 23 s at constant speed. At what average rate does the force from the cable do work on the cab?

EXPRESS YOUR ANSWER AS BOTH IN WATT AND HORSEPOWER.

ANS: 268434.8W and 359.8hp

ADVANCED PROBLEMS

AP1:

62 A 250 g block is dropped onto a relaxed vertical spring that has a spring constant of $k = 2.5$ N/cm (Fig. 7-46). The block becomes attached to the spring and compresses the spring 12 cm before momentarily stopping. While the spring is being compressed, what work is done on the block by (a) the gravitational force on it and (b) the spring force? (c) What is the speed of the block just before it hits the spring? (Assume that friction is negligible.) (d) If the speed at impact is doubled, what is the maximum compression of the spring?

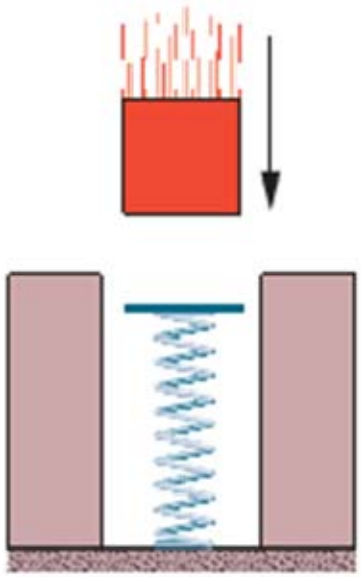


Figure 7-46 Problem 62.

ANS: A) 0.3J B) -1.8J C) 3.46 m/s D) 22.88cm

AP2:

65 In Fig. 7-47, a cord runs around two massless, frictionless pulleys. A canister with mass $m = 20$ kg hangs from one pulley, and you exert a force $\vec{F}$ on the free end of the cord. (a) What must be the magnitude of $\vec{F}$ if you are to lift the canister at a constant speed? (b) To lift the canister by 2.0 cm, how far must you pull the free end of the cord? During that lift, what is the work done on the canister by (c) your force (via the cord) and (d) the gravitational force? (*Hint:* When a cord loops around a pulley as shown, it pulls on the pulley with a net force that is twice the tension in the cord.)

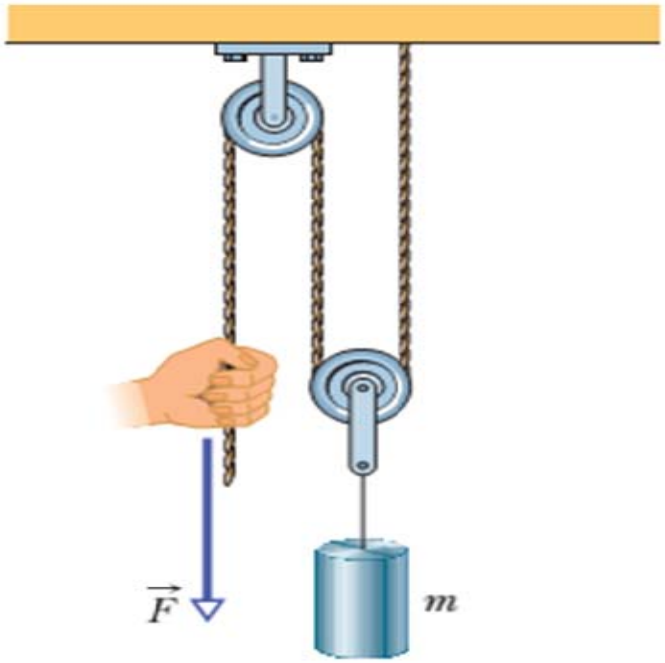


Figure 7-47 Problem 65.

ANS: A) 98N B) 4cm C) 3.92J D) -3.92J