Phys 103

Chapter 5

The Laws of Motion

By

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LECTURE OUTLINE

PROBLEMS

Sections 5.1 through 5.6

3. A 3.00-kg object undergoes an acceleration given by

a =(2.00ˆi + 5.00ˆj) m/s2.

Find the resultant force acting on it and the magnitude of the resultant force.

SOLUTIONS TO PROBLEM:

$$\sum \boldsymbol{F} = \boldsymbol{ma}$$

$$|\sum \boldsymbol{F}| = \sqrt{\boldsymbol{F_x}^2 + \boldsymbol{F_y}^2}$$

PROBLEMS

Sections 5.1 through 5.6

7. An electron of mass 9.11 1 10#31 kg has an initial speed of 3.00 1 105 m/s. It travels in a straight line, and its speed increases to 7.00 1 105 m/s in a distance of 5.00 cm. Assuming its acceleration is constant, (a) determine the force exerted on the electron and (b) compare this force with the weight of the electron, which we neglected.

SOLUTIONS TO PROBLEM:

$$\sum \boldsymbol{F} = \boldsymbol{ma}\,, {v_f}^2 = {v_i}^2 + 2ax_f$$

$$F_f = mg$$

PROBLEMS

Sections 5.1 through 5.6

11. Two forces **F**1 and **F**2 act on a 5.00-kg object. If *F*1 = 20.0 N and *F*2 =15.0 N, find the accelerations in (a) and (b) of Figure P5.11.

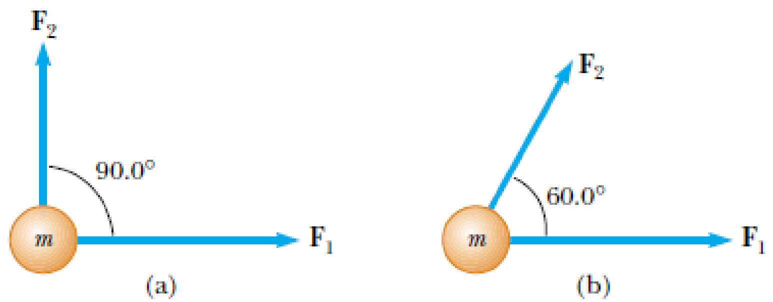


Figure P5.11

SOLUTIONS TO PROBLEM:

$\sum \boldsymbol{F} = F_1 + F_2 \, , \quad \sum \boldsymbol{F} = \boldsymbol{ma}$

$$|\boldsymbol{a}| = \sqrt{\boldsymbol{a_x}^2 + \boldsymbol{a_y}^2}.$$

$$\theta = tan^{-1}\frac{a_y}{a_x}.$$

$F_{2x} = 15\cos 60$

$F_{2y} = 15\, sin\, 60$

$\boldsymbol{F_2} = F_{2x} i + F_{2y} j$

$\sum \boldsymbol{F} = F_1 + F_2 = m\boldsymbol{a}$

$|\boldsymbol{a}|$ and θ

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

16. A 3.00-kg object is moving in a plane, with its x and y coordinates given by $x=5t^2 - 1$ and $y=3t^3 + 2$, where x and y are in meters and t is in seconds. Find the magnitude of the net force acting on this object at $t = 2.00$ s.

SOLUTIONS TO PROBLEM:

$$v_{\mathrm{x}} = \frac{\mathrm{d}x}{\mathrm{dt}}, v_y = \frac{\mathrm{d}y}{\mathrm{dt}}$$

$$\mathrm{a_x} = \frac{\mathrm{dv_x}}{\mathrm{dt}}, \mathrm{a}_y = \frac{\mathrm{dv}_y}{\mathrm{dt}}$$

$$\sum F_{\mathrm{x}} = \boldsymbol{m}\mathrm{a_x}, \sum F_y = \boldsymbol{m}\mathrm{a}_y$$

$$\left| \sum \boldsymbol{F} \right| = \sqrt{\boldsymbol{F_x}^2 + \boldsymbol{F_y}^2}$$

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

18. A bag of cement of weight 325 N hangs from three wires as suggested in Figure P5.18. Two of the wires make angles θ_1= 60.0° and θ_2= 25.0° with the horizontal. If the system is in equilibrium, find the tensions T_1, T_2, and T_3 in the wires.

SOLUTIONS TO PROBLEM:

$T_{3=}\ F_g$

$T_1 \sin \theta_1 + T_2 \sin \theta_{2=} F_g$

$T_1 \cos \theta_1 = T_2 \cos\theta_2$

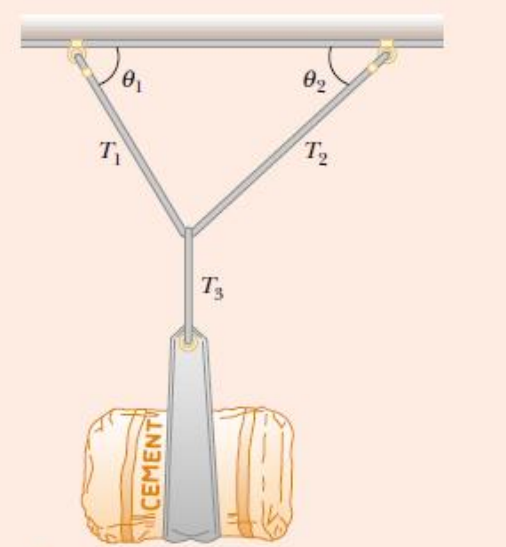


Figure P5.18 Problems 18 and 19.

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

24. A 5.00-kg object placed on a frictionless, horizontal table is connected to a string that passes over a pulley and then is fastened to a hanging 9.00-kg object, as in Figure P5.24. Draw free-body diagrams of both objects. Find the acceleration of the two objects and the tension in the string.

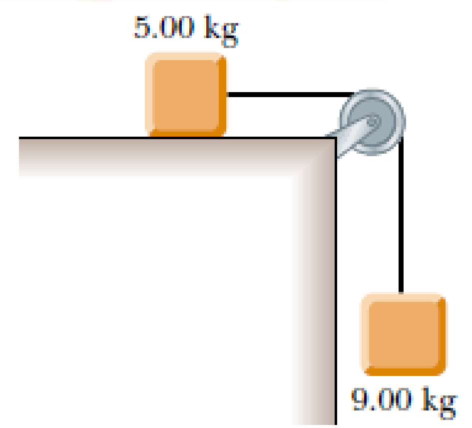
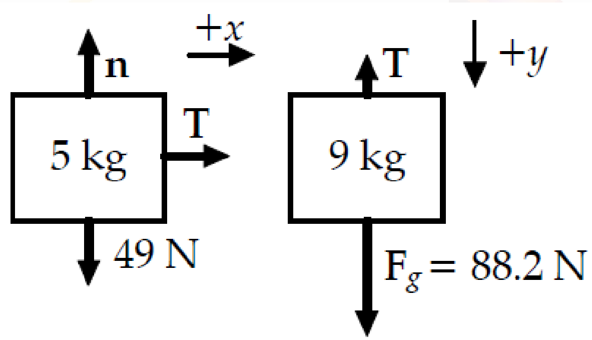


Figure P5.24 Problems 24 and 43.

SOLUTIONS TO PROBLEM:

$\sum F_x = m a_x, \sum F_y = m a_y$

88.2N-T=9a



PROBLEMS

Section 5.7 Some Applications of Newton's Laws

25. A block is given an initial velocity of 5.00 m/s up a frictionless 20.0° incline (Fig. P5.22). How far up the incline does the block slide before coming to rest?

SOLUTIONS TO PROBLEM:

After it leaves your hand, the block's speed changes onlybecause of one component of its weight:

$$\sum F_x = \boldsymbol{m} a_x - mgsin20 = ma$$

$$v_f^{\ 2} = v_i^{\ 2} + 2a\left(x_f - x_i\right) taking\ v_f = 0$$

$$x_{f=?}$$

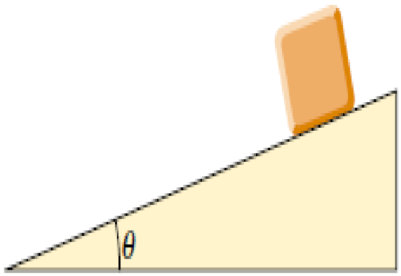


Figure P5.22 Problems 22 and 25.

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

26. Two objects are connected by a light string that passes over a frictionless pulley, as in Figure P5.26. Draw free-body diagrams of both objects. If the incline is frictionless and if m_1 = 2.00 kg, m_2 = 6.00 kg, and θ = 55.0°, find (a) the accelerations of the objects, (b) the tension in the string, and (c) the speed of each object 2.00 s after being released from rest.

SOLUTIONS TO PROBLEM:

$$\sum F_x = m_2 g sin\boldsymbol{\theta} - T = m_2\, a$$

And $T - m_1 g = m_1\, a$

$v_i = 0 \;\; v_f = at$

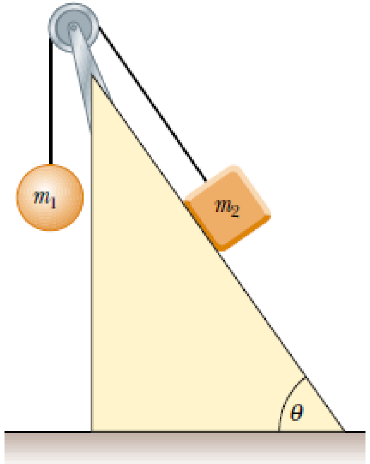
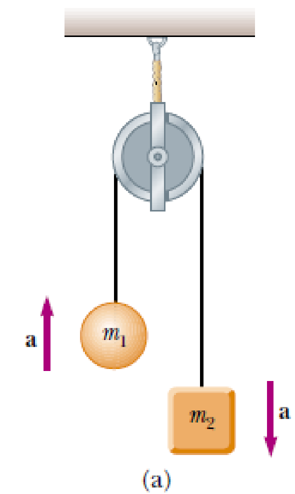


Figure P5.26

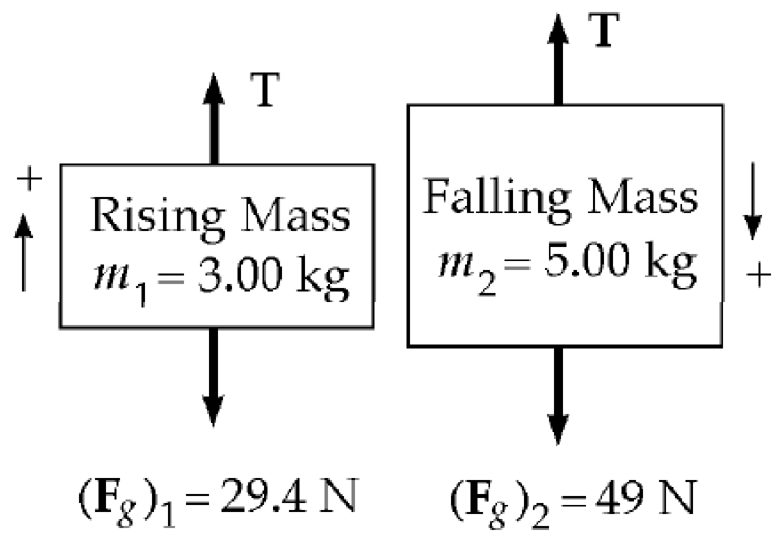
PROBLEMS

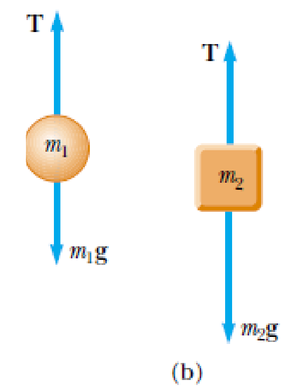
Section 5.7 Some Applications of Newton's Laws

28. Two objects with masses of 3.00 kg and 5.00 kg are connected by a light string that passes over a light frictionless pulley to form an Atwood machine, as in Figure 5.14a. Determine (a) the tension in the string, (b) the acceleration of each object, and (c) the distance each object will move in the first second of motion if they start from rest.



SOLUTIONS TO PROBLEM:

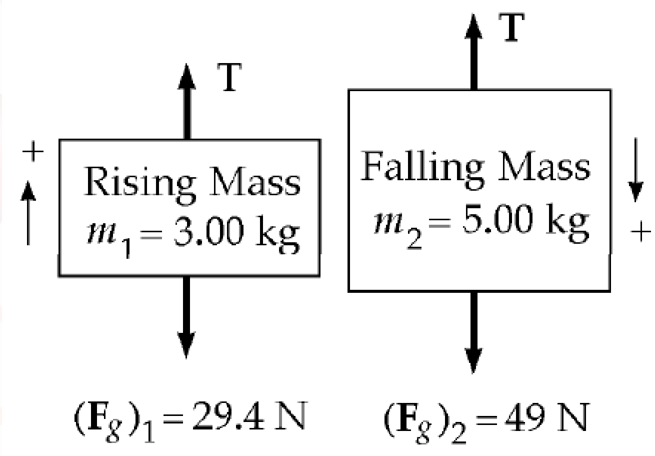




PROBLEMS

Section 5.7 Some Applications of Newton's Laws

28.



SOLUTIONS TO PROBLEM:

First, consider the 3.00 kg rising mass. The forces on it are the tension, *T*, and its weight, 29.4 N. With the upward direction as positive, the second law becomes

$$\sum F_y = may : T - 29 = 3a$$

The forces on the falling 5.00 kg mass are its weight and *T*, and its acceleration is the same as that of the rising mass. Calling the positive direction down for this mass, we have

$\sum F_y = may : 49 - T = 5a$

$$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2 = \frac{1}{2}a_y t^2$$

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

30. In the Atwood machine shown in Figure 5.14a, m_1 = 2.00 kg and m_2 = 7.00 kg. The masses of the pulley and string are negligible by comparison. The pulley turns without friction and the string does not stretch. The lighter object is released with a sharp push that sets it into motion at v_i = 2.40 m/s downward. (a) How far will m_1 descend below its initial level? (b) Find the velocity of m_1 after 1.80 seconds.

SOLUTIONS TO PROBLEM:

PROBLEMS

Section 5.7 Some Applications of Newton's Laws

31. In the system shown in Figure P5.31, a horizontal force $\mathbf{F}_x$ acts on the 8.00-kg object. The horizontal surface is frictionless.

(a) For what values of F_x does the 2.00-kg object accelerate upward? (b) For what values of F_x is the tension in the cord zero? (c) Plot the acceleration of the 8.00-kg object versus F_x. Include values of F_x from -100 N to +100 N.

SOLUTIONS TO PROBLEM:

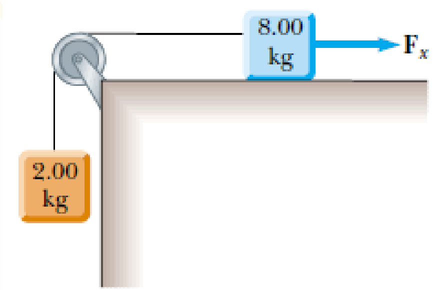


Figure P5.31

PROBLEMS

Section 5.8 Forces of Friction

37. A car is traveling at 50.0 mi/h on a horizontal highway. (a) If the coefficient of static friction between road and tires on a rainy day is 0.100, what is the minimum distance in which the car will stop? (b) What is the stopping distance when the surface is dry and $\mu_s = 0.600$?

SOLUTIONS TO PROBLEM:

PROBLEMS

Section 5.8 Forces of Friction

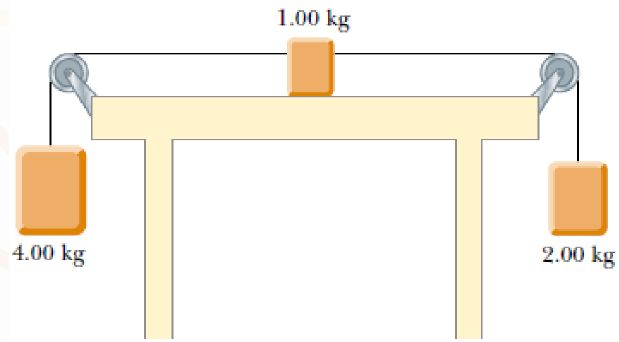
41. A 3.00-kg block starts from rest at the top of a 30.0° incline and slides a distance of 2.00 m down the incline in 1.50 s. Find (a) the magnitude of the acceleration of the block, (b) the coefficient of kinetic friction between block and plane, (c) the friction force acting on the block, and (d) the speed of the block after it has slid 2.00 m.

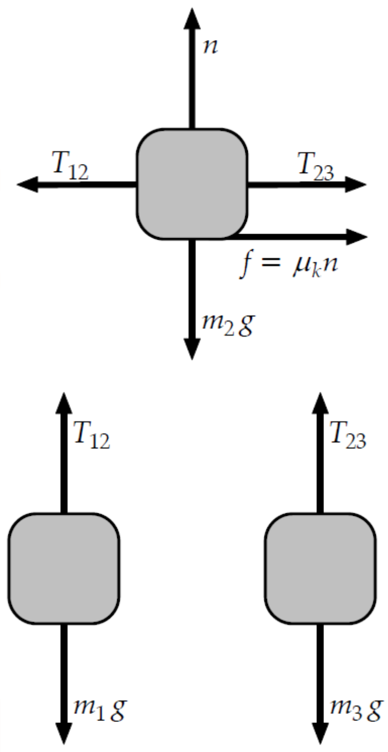
SOLUTIONS TO PROBLEM:

PROBLEMS

Section 5.8 Forces of Friction

44. Three objects are connected on the table as shown in Figure P5.44. The table is rough and has a coefficient of kinetic friction of 0.350. The objects have masses of 4.00 kg, 1.00 kg, and 2.00 kg, as shown, and the pulleys are frictionless. Draw free-body diagrams of each of the objects. (a) Determine the acceleration of each object and their directions. (b) Determine the tensions in the two cords.





SOLUTIONS TO PROBLEM:

PROBLEMS

Section 5.8 Forces of Friction

44.

SOLUTIONS TO PROBLEM:

Let a represent the positive magnitude of the acceleration $-a\hat{\mathbf{j}}$ of m_1, of the acceleration $-a\hat{\mathbf{i}}$ of m_2, and of the acceleration $+a\hat{\mathbf{j}}$ of m_3. Call T_{12} the tension in the left rope and T_{23} the tension in the cord on the right.

For m_1, $\sum F_y = ma_y$ $+T_{12} - m_1 g = -m_1 a$

For m_2, $\sum F_x = ma_x$ $-T_{12} + \mu_k n + T_{23} = -m_2 a$

and $\sum F_y = ma_y$ $n - m_2 g = 0$

for m_3, $\sum F_y = ma_y$ $T_{23} - m_3 g = +m_3 a$

we have three simultaneous equations

$$-T_{12} + 39.2\text{ N} = (4.00\text{ kg})a$$
$$+T_{12} - 0.350(9.80\text{ N}) - T_{23} = (1.00\text{ kg})a$$
$$+T_{23} - 19.6\text{ N} = (2.00\text{ kg})a.$$

PROBLEMS

Section 5.8 Forces of Friction

45. Two blocks connected by a rope of negligible mass are being dragged by a horizontal force **F** (Fig. P5.45). Suppose that $F = 68.0$ N, $m1 = 12.0$ kg, $m2 = 18.0$ kg, and the coefficient of kinetic friction between each block and the surface is 0.100. (a) Draw a free-body diagram for each block. (b) Determine the tension T and the magnitude of the acceleration of the system.

SOLUTIONS TO PROBLEM:

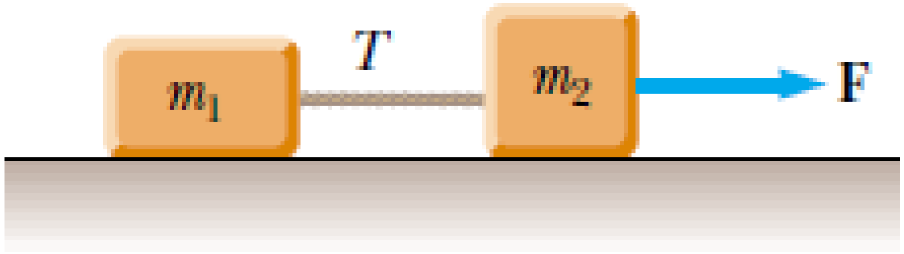


Figure P5.45

PROBLEMS

Section 5.8 Forces of Friction

46. A block of mass 3.00 kg is pushed up against a wall by a force **P** that makes a 50.0° angle with the horizontal as shown in Figure P5.46. The coefficient of static friction between the block and the wall is 0.250. Determine the possible values for the magnitude of **P** that allow the block to remain stationary.

SOLUTIONS TO PROBLEM:

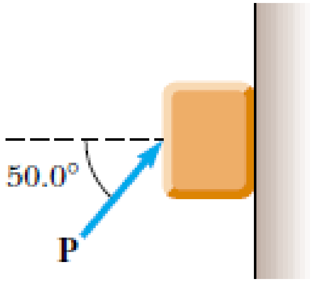


Figure P5.46

PROBLEMS

Additional Problems

58. Review problem. A block of mass $m = 2.00$ kg is released from rest at $h = 0.500$ m above the surface of a table, at the top of a $\theta = 30.0°$ incline as shown in Figure P5.58. The frictionless incline is fixed on a table of height $H = 2.00$ m. (a) Determine the acceleration of the block as it slides down the incline. (b) What is the velocity of the block as it leaves the incline? (c) How far from the table will the block hit the floor? (d) How much time has elapsed between when the block is released and when it hits the floor? (e) Does the mass of the block affect any of the above calculations?

SOLUTIONS TO PROBLEM:

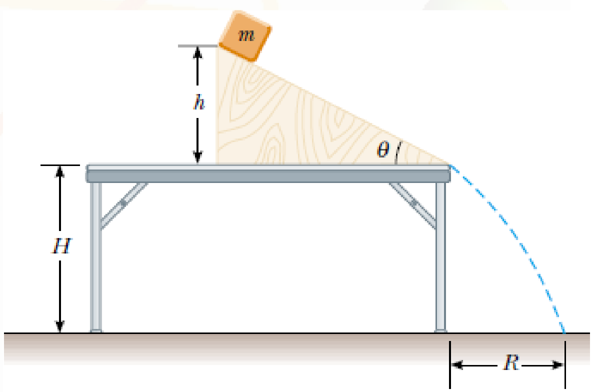


Figure P5.58 Problems 58 and 70.

Thank You


ACKNOWLEDGEMENTS