CSD2301 Practice Solutions
4. Newton's Laws of Motion

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Practice Question 1

What magnitude of net force is required to give a 135 kg refrigerator an acceleration of magnitude 1.40 m/s^2?

$$F = ma = (135\,\text{kg})(1.40\,\text{m/s}^2) = 189\,\text{N}.$$

Practice Question 2

A car with a mass of 1,000 kg is moving at a velocity of 10 m/s and is brought to a stop in 5 seconds. What is the brake force needed?

$$v = u + at$$

$$a = \frac{v-u}{t} = \frac{0-10}{5} = -2\ m/s^2$$

$$F = ma = 1000 \times (-2) = -2000\ N$$

ANS: 2000 N

Practice Question 3

A 2 kg object is initially at rest and is propelled upwards by a force of 10 N for 5 seconds. What is the final velocity of the object and how high does it rise?

$$a = \frac{F}{m} = \frac{10}{2} = 5 \text{ m/s}^2$$

$$v = u + at = 0 + 5(5) = 25 \text{ m/s (ans)}$$

$$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(5)(5)^2 = 62.5 \text{ m (ans)}$$

Practice Question 4

A hockey puck with mass 0.160 kg is at rest at the origin (x=0) on the horizontal, frictionless surface of the rink. At time t=0, a player applies a force of 0.250 N to the puck, parallel to the x-axis; he continues to apply this force until t = 2.00 s. a) What are the **position** and **speed** of the puck at t = 2.00 s? b) If the same force is again applied at t = 5.00 s, what are the **position** and **speed** of the puck at t = 7.00 s?

a) During the first 2.00 s, the acceleration of the puck is $F/m = 1.563\,\text{m/s}^2$ (keeping an extra figure). At $t = 2.00\,\text{s}$, the speed is $at = 3.13\,\text{m/s}$ and the position is $at^2/2 = vt/2 = 3.13\,\text{m}$. b) The acceleration during this period is also $1.563\,\text{m/s}^2$, and the speed at 7.00 s is $3.13\,\text{m/s} + (1.563\,\text{m/s}^2)(2.00\,\text{s}) = 6.26\,\text{m/s}$. The position at $t = 5.00\,\text{s}$ is $x = 3.13\,\text{m} + (3.13\,\text{m/s})(5.00\,\text{s} - 2.00\,\text{s}) = 125\,\text{m}$, and at $t = 7.00\,\text{s}$ is

$$12.5\,\text{m} + (3.13\,\text{m/s})(2.00\,\text{s}) + (1/2)(1.563\,\text{m/s}^2)(2.00\,\text{s})^2 = 21.89\,\text{m},$$

or 21.9 m to three places.

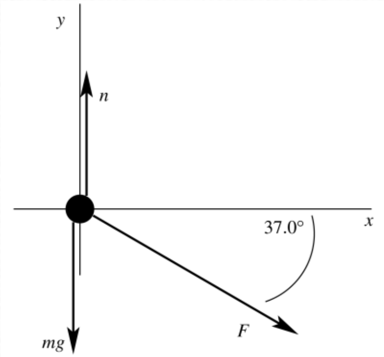
$v = u + at$

Should be 12.5

$x = x_0 + ut + \frac{1}{2}at^2$

Practice Question 5

A chair of mass 12.0 kg sits on the floor. You push the chair with a force F = 40.0 N that is directed at an angle of 37.0° below the horizontal axis and the chair slides along the floor. a) Draw a clearly labelled free body diagram for the chair. b) Calculate the normal force that the floor exerts on the chair.



b) For the chair, $a_y = 0$ so $\sum F_y = ma_y$ gives

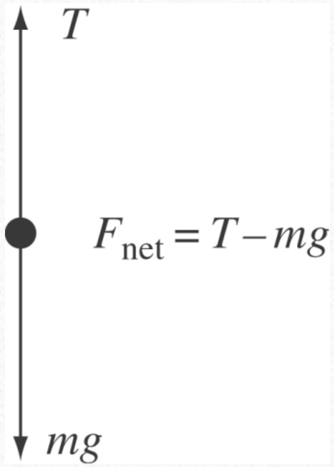
$$n - mg - F\sin 37° = 0$$

$$n = 142\,\text{N}$$

Practice Question 6

An elevator with very worn cables has a total mass of 2200 kg, and the cables sustaining the elevator can withstand a maximum tension of 28000 N. a) Draw the free body diagram for the elevator. What is the maximum upwards acceleration for the elevator if the cables are not to break? b) What would be the answer to part (a) if the elevator were on the moon, where g = 1.62 m/s^2

a)



The maximum acceleration would occur when the tension in the cables is a maximum,

$$a = \frac{F_{\text{net}}}{m} = \frac{T - mg}{m} = \frac{T}{m} - g = \frac{28{,}000\ \text{N}}{2200\,\text{kg}} - 9.80\,\text{m/s}^2 = 2.93\,\text{m/s}^2.$$

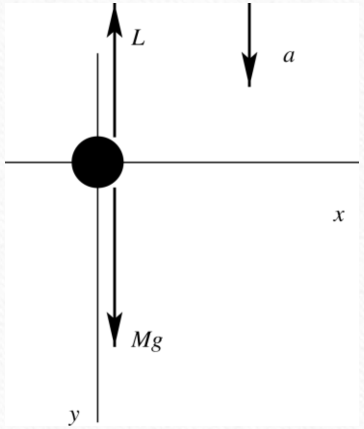
b)

$$\frac{28{,}000\ \text{N}}{2200\ \text{kg}} - 1.62\ \text{m/s}^2 = 11.1\,\text{m/s}^2.$$

Practice Question 7

A hot-air balloon consists of a basket, one passenger and some cargo. Let the total mass be M. Even though there is an upward lift force on the balloon, the balloon is initially accelerating downward at a rate of g/3. a) Draw a free body diagram for the descending balloon. b) Find the upward lift force in terms of the total weight Mg. c) The passenger notices that he is in trouble and needs to go up. What fraction of the total weight must he drop overboard so that the balloon can accelerate upward at a rate of g/2? (Assume that upward lift remains the same)

a)



b) $\sum F_y = ma_y$

$Mg - L = M(g/3)$

$L = 2Mg/3$

For part b, solutions take downwards as +y.

For part c, solutions take upwards as +y.

c) $L - mg = m(g/2)$, where m is the mass remaining.

$L = 2Mg/3$, so $m = 4M/9$. Mass $5M/9$ must be dropped overboard.

The End