Phys 100
Fall 2023

# Concepts of Physics: Homework 4

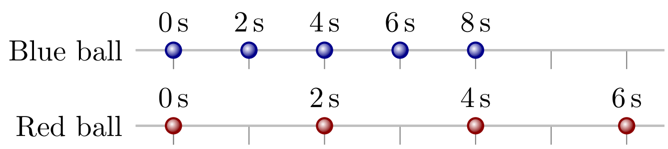
Due: 25 September 2023

## 1 Ball rolling in a circle

A circular groove is cut into a horizontal surface. A ball rolls along the circular groove at a constant speed. Is the net force on the ball zero or non-zero? Explain your answer.

## 2 Rolling balls

Two balls roll in straight lines along a surface. The locations of each ball are photographed at instants 2 s apart. Explain whether the net force on the red ball is smaller than, larger than or the same as the net force on the blue ball, during the period from 0 s to 6 s.




## 3 Walrus versus dog

A walrus, with mass 500 kg, and a dog, with mass 50 kg, both lie on a horizontal sheet of ice. One person pushes on the walrus, another on the dog. The walrus has acceleration $0.20\,\mathrm{m/s^2}$ and the dog has acceleration $3.0\,\mathrm{m/s^2}$. Is the net force on the walrus larger than, smaller than or the same as that on the dog? Explain your answer.

## 4 Forces and motion

Zane, with mass 70 kg, pushes on Yvonne who is on a skateboard. Yvonne and the skateboard are initially at rest and have a combined mass of 50 kg. Zane then pushes on Yvonne with a horizontal force that has size 150 N.

a) Determine the acceleration of Yvonne.

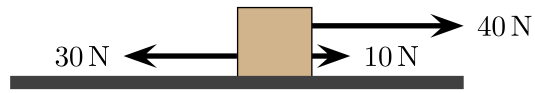
b) Determine the speed of Yvonne 1.0 s after Zane begins to push on her.

c) Determine the speed of Yvonne 3.0 s after Zane begins to push on her.

d) Suppose that Zane were able to push like this for 8.0 s. Determine Yvonne's speed. Does this seem possible? Recall that a world class sprinter runs 100 m in 10 s.

## 5 Multiple forces and motion

A 5.0 kg box can slide along a frictionless horizontal surface. Three people pull horizontally on the box with the indicated forces.




a) Determine the net force on the box.

b) Determine the acceleration of the box.

## 6 Pushing sleds

Two people, Angela and Bryce, push heavily laden sleds across frozen ponds. The sleds are identical and have identical masses. There is no friction between the ice and the sleds. Air resistance can be ignored. During a particular period lasting for 30 s, Angela pushes her sled from rest to a speed of 5 m/s while Bryce pushes his sled at a constant speed of 10 m/s. How does the force which Angela exerts on her sled compare to that which Bryce exerts on his sled (same, larger, smaller)? Explain your answer.

## 7 Raising a cube of titanium

A heavy cube of titanium lies on an open hand that is held horizontal.

a) The hand holds the cube at rest. Is the net force on the cube zero or not? Explain if the force exerted by the hand is larger than, smaller than or the same as the gravitational force exerted by Earth.

b) The hand raises the cube and it moves upward at a constant rate. Is the net force on the cube zero or not? Explain if the force exerted by the hand is larger than, smaller than or the same as the gravitational force exerted by Earth.

## 8 Ping-pong ball terminal velocity

Objects that fall in the presence of air resistance accelerate until they reach *terminal velocity*. This is a state where they fall with constant speed. A ping-pong ball with mass 0.0027 kg has terminal velocity of about 9.5 m/s.

a) Consider the period between the moment that the ball is released and when it reaches terminal velocity. Do you expect that, as the ball speeds up, the size of the air resistance force increases, decreases or stays constant?

b) Initially the ball falls with acceleration 9.80 $m/s^2$. Determine the size of the air resistance force at this moment.

c) Determine the size of the air resistance force when the ball falls with terminal velocity.

d) Does the air resistance force increase or decrease after the ball reaches terminal velocity? Explain your answer.

**9** Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 5, Conceptual Exercise 2, page 115.

## 10 Reading exercise: gravity

Read section 5.1 (pages 95 – 97) of the text.

a) Aristotelian physics would say that no forces are required to move the moon in a circular orbit since this is its natural motion. Does this agree with the notions of Galileo and Newton regarding the motion of objects? Explain your answer.

b) What is the direction of the force exerted by Earth on the falling apple? What is the direction of the force exerted by Earth on the orbiting moon?

c) Do Concept Check 1 before looking at the answer and check whether you were correct or not. Note that "a 2 N apple" means that the gravitational force exerted on the apple is 2 N.

d) Do Concept Check 3 before looking at the answer and check whether you were correct or not.