Self-Study Problems

MULTIPLE CHOICE QUESTIONS

MCQ1: The net force on a moving object suddenly becomes zero and remains zero. The object will
(A) stop abruptly
(B) reduce speed gradually
(C) continue at constant speed
(D) continue at constant velocity
(E) reduce speed abruptly

Answer (D):
According to Newton’s 1st law: *A body in uniform motion remains in uniform motion, and a body at rest remains at rest, unless acted on by a nonzero net force.* The object is moving ⇒ when $\vec{F}_{\text{net}}$ becomes zero it will continue to move at constant velocity.

MCQ2: A 1.0-kg body at rest experiences a force of 5.0N exerted in the positive x-direction for 2.0 s, followed by a force of 10N exerted in the negative x-direction for 1.0 s. Its resulting speed will be:
(A) –20 m/s
(B) –10 m/s
(C) 0 m/s
(D) +10 m/s
(E) +20 m/s

Answer (C):
The first 2 seconds: $F = ma \Rightarrow a = \frac{F}{m} = \frac{5}{1} = 5.1 \text{ m/s}^2$; $\Delta v = at \Rightarrow \Delta v = 10 \text{ m/s}$

Third second: $a = \frac{F}{m} = \frac{-10}{1} = -10 \text{ m/s}^2 \Rightarrow \Delta v = at = -10 \cdot 1 = -10 \text{ m/s}$

If the body starts from rest and change by positive 10 and negative 10, we are back at rest

MCQ3: A 4 kg object, moving in the negative x-direction at speed 10 m/s encounters a force shown in the graph to the right. What is the instantaneous velocity of the object at t = 10 s?
(A) 10 m/s
(B) 20 m/s
(C) 30 m/s
(D) 40 m/s

Answer (C):
Acceleration $a = \frac{\Delta v}{\Delta t} = \frac{5}{4} = 5 \text{ m/s}^2$

$\Delta v = v_0 + at = -10 + 5 \cdot 10 = 40 \text{ m/s}$

MCQ4: The three forces represented in the figure to the right act on an object. What is the direction of the acceleration of the object?
(A) 11.3° clockwise from the positive y-axis
(B) 11.3° counterclockwise from the positive y-axis
(C) 11.3° clockwise from the negative x-axis
(D) 78.7° counterclockwise from the positive x-axis
(E) The mass of the object must be known to answer the question

Answer (B):
$F_{x,\text{net}} = F_{1,x} + F_{2,x} + F_{2,x} = 4 + (-2) + (-3) = -1 \text{ N}$

$F_{y,\text{net}} = F_{1,y} + F_{2,y} + F_{2,y} = 4 + 3 + (-2) = 5 \text{ N}$

$\Rightarrow \vec{F}_{\text{net}} (\text{-1 N, 5 N})$ in the 2nd quadrant and forms an angle $\theta = \tan^{-1} \left( \frac{5}{-1} \right) = 78.7^\circ$ clockwise from the negative x-axis, or $90^\circ - 78.7^\circ = 11.3^\circ$ counterclockwise from the positive y-axis. $\vec{F}_{\text{net}} = ma \Rightarrow \vec{F}_{\text{net}}$ and $\vec{a}$ are in the same direction

MCQ5: A garbage truck crashes head-on into a Volkswagen and the two come to rest in a cloud of flies. Which experiences the greater impact force?
(A) The truck
(B) The Volkswagen
(C) Both experience the same force
(D) Not enough information given.

Answer (C):
According to 3rd Newton's law both experience the same force
SHORT PROBLEMS

SP1: Figure to the right gives, as a function of time \( t \), the force component \( F_x \) that acts on a 3.00 kg ice block that can move only along the \( x \)-axis. At \( t = 0 \), the block is moving in the positive direction of the axis with a speed of 3.0 m/s.

(a) Find the maximum velocity of the block.

Solution:
The block accelerates from \( t = 0 \) s to 6 s and the change in its velocity
\[
\Delta v = \text{area under } a \text{-vs-} t \text{ curve where } a = F_x/m
\]
\[
\Rightarrow \Delta v = \frac{2}{3} \times (2 - 0) + \frac{1}{2} ((6 - 2)/3) \times (2 - 0) + (6/3) \times (5 - 2) + \frac{1}{2} (6/3) \times (6 - 5) = 9.7 \text{ m/s}
\]
\[
v = v_0 + \Delta v = 3 + 9.7 = 12.7 \text{ m/s}
\]

(b) What is the velocity of the block at \( t = 11 \) s?

Solution:
\[
\Delta v = \text{area under } a \text{-vs-} t \text{ curve where } a = F_x/m. \text{ From the diagram follows that 1 square corresponds to the change in velocity by } (1\text{N}\times\text{s})/(3 \text{ kg}) = (1/3) \text{ m/s}
\]
\[
\Rightarrow \Delta v = \frac{8}{3} + \frac{18}{3} + \frac{3}{3} - \frac{14}{3} = 5 \text{ m/s}
\]
\[
v = v_0 + \Delta v = 3 + 5 = 8 \text{ m/s}
\]

SP2: A 50 kg passenger rides in an elevator cab that starts from rest on the ground floor of a building at \( t = 0 \) and rises to the top floor during a 10 s interval. The cab's acceleration as a function of the time is shown to the right, where positive values of the acceleration mean that it is directed upward.

(a) Find the magnitude and direction (up or down) of the maximum force on the passenger from the floor.

Solution: (see sketch to the right)
There, \( F_1 = mg \) is the force due to gravity, \( F_2 \) is the force on the floor from passenger and \( F_3 \) is the force on the passenger from the floor.
According to Newton’s second law \( F_{\text{net}} = ma = F_3 - F_1 \Rightarrow \) the maximum force on the passenger from the floor
\[
F_{3,\text{max}} = ma_{\text{max}} + F_1 = ma_{\text{max}} + mg = m(a_{\text{max}} + g)
\]
\[
F_{3,\text{max}} = 50 \times (2 + 9.81) = 590 \text{ N (directed upward)}
\]

(b) Find the magnitude and direction (up or down) of the minimum force on the floor from the passenger.

Solution:
According to Newton’s second law \( F_{\text{net}} = -ma = F_3 - F_1 \Rightarrow \) the minimum force on the passenger from the floor
\[
F_{3,\text{min}} = -ma_{\text{min}} + F_1 = -ma_{\text{min}} + mg = m(g - a_{\text{min}})
\]
\[
F_{3,\text{min}} = 50 \times (9.81 - 3) = 341 \text{ N (directed upward)}
\]
According to Newton’s 3rd law \( F_{2,\text{min}} = -F_{3,\text{min}} \Rightarrow \) the minimum force on the floor from the passenger
\[
F_{2,\text{min}} = -341 \text{ N i.e. directed downward}
\]