ANSWERS

Chapter 1

1.1 (a) 10^{-6} ; (b) 1.5×10^{4} ; (c) 5 ; (d) 11.3, 1.13×10^{4}.

1.2 (a) 10^{7} ; (b) 10^{-16} ; (c) 3.9×10^{4} ; (d) 6.67×10^{-8}.

1.5 500

1.6 (c)

1.7 0.035 mm

1.9 94.1

1.10 (a) 1 ; (b) 3 ; (c) 4 ; (d) 4 ; (e) 4 ; (f) 4.

1.11 8.72 m^2; 0.0855 m^3

1.12 (a) 2.3 kg ; (b) 0.02 g

1.13 The correct formula is $m = m_0 (1 - v^2/c^2)^{-1/2}$

1.14 $\cong 3 \times 10^{-7}$ m^3

1.15 $\cong$ 10^{4}; intermolecular separation in a gas is much larger than the size of a molecule.

1.16 Near objects make greater angle than distant (far off) objects at the eye of the observer. When you are moving, the angular change is less for distant objects than nearer objects. So, these distant objects seem to move along with you, but the nearer objects in opposite direction.

1.17 1.4×10^{3} kg m^{-3}; the mass density of the Sun is in the range of densities of liquids / solids and *not* gases. This high density arises due to inward gravitational attraction on outer layers due to inner layers of the Sun.

Chapter 2

2.1 (a), (b)

2.2 (a) A....B, (b) A....B, (c) B....A, (d) Same, (e) B....A....once.

2.4 37 s

2.5 3.06 m s^{-2}; 11.4 s

2.6 (a) Vertically downwards; (b) zero velocity, acceleration of 9.8 m s^{-2} downwards; (c) $x > 0$ (upward and downward motion); $v < 0$ (upward), $v > 0$ (downward), $a > 0$ throughout; (d) 44.1 m, 6 s.

2.7 (a) True;, (b) False; (c) True (if the particle rebounds instantly with the same speed, it implies infinite acceleration which is unphysical); (d) False (true only when the chosen positive direction is along the direction of motion)

2.10 (a) 5 km h^{-1}, 5 km h^{-1}; (b) 0, 6 km h^{-1}; (c) $\frac{15}{8}$ km h^{-1}, $\frac{45}{8}$ km h^{-1}

2.11 Because, for an arbitrarily small interval of time, the magnitude of displacement is equal to the length of the path.

2.12 All the four graphs are impossible. (a) a particle cannot have two different positions at the same time; (b) a particle cannot have velocity in opposite directions at the same time; (c) speed is always non-negative; (d) total path length of a particle can never decrease with time. (Note, the arrows on the graphs are meaningless).

2.13 No, wrong. x- t plot does not show the trajectory of a particle. Context: A body is dropped from a tower ($x = 0$) at $t = 0$.

2.14 105 m s^{-1}

2.15 (a) A ball at rest on a smooth floor is kicked, it rebounds from a wall with reduced speed and moves to the opposite wall which stops it; (b) A ball thrown up with some initial velocity rebounding from the floor with reduced speed after each hit; (c) A uniformly moving cricket ball turned back by hitting it with a bat for a very short time-interval.

2.16 $x < 0$, $v < 0$, $a > 0$; $x > 0$, $v > 0$, $a < 0$; $x < 0$, $v > 0$, $a > 0$.

2.17 Greatest in 3, least in 2; $v > 0$ in 1 and 2, $v < 0$ in 3.

2.18 Acceleration magnitude greatest in 2; speed greatest in 3; $v > 0$ in 1, 2 and 3; $a > 0$ in 1 and 3, $a < 0$ in 2; $a = 0$ at A, B, C, D.

Chapter 3

3.1 Volume, mass, speed, density, number of moles, angular frequency are scalars; the rest are vectors.

3.2 Work, current

3.3 Impulse

3.4 Only (c) and (d) are permissible

3.5 (a) T, (b) F, (c) F, (d) T, (e) T

3.6 Hint: The sum (difference) of any two sides of a triangle is never less (greater) than the third side. Equality holds for collinear vectors.

3.7 All statements except (a) are correct

3.8 400 m for each; B

3.9 (a) O; (b) O; (c) 21.4 km h^{-1}

3.10 Displacement of magnitude 1 km and direction 60° with the initial direction; total path length = 1.5 km (third turn); null displacement vector; path length = 3 km (sixth turn); 866 m, 30°, 4 km (eighth turn)

3.11 (a) 49.3 km h^{-1} ; (b) 21.4 km h^{-1}. No, the average speed equals average velocity magnitude only for a straight path.

3.12 150.5 m

3.13 50 m

3.14 9.9 m s^{-2}, along the radius at every point towards the centre.

3.15 6.4 g

3.16 (a) False (true only for uniform circular motion)

(b) True, (c) True.

3.17 (a) $\mathbf{v}(t) = (3.0\,\hat{\mathbf{i}} - 4.0t\,\hat{\mathbf{j}})$ $\hat{\mathbf{a}}(t) = -4.0\,\hat{\mathbf{j}}$

(b) 8.54 m s^{-1}, 70° with x-axis.

3.18 (a) 2 s, 24 m, 21.26 m s^{-1}

3.19 $\sqrt{2}$, 45° with the x-axis; $\sqrt{2}$, – 45° with the x - axis, $\left(5/\sqrt{2},\ -1/\sqrt{2}\right)$.

3.20 (b) and (e)

3.21 Only (e) is true

3.22 182 m s^{-1}

Chapter 4

4.1 (a) to (d) No net force according to the First Law
(e) No force, since it is far away from all material agencies producing electromagnetic and gravitational forces.

4.2 The only force in each case is the force of gravity, (neglecting effects of air) equal to 0.5 N vertically downward. The answers do not change, even if the motion of the pebble is not along the vertical. The pebble is not at rest at the highest point. It has a constant horizontal component of velocity throughout its motion.

4.3 (a) 1 N vertically downwards (b) same as in (a)
(c) same as in (a); force at an instant depends on the situation at that instant, not on history.
(d) 0.1 N in the direction of motion of the train.

4.4 (i) T

4.5 $a = -2.5$ m s^{-2}. Using $v = u + at$, $0 = 15 - 2.5\,t$ i.e., $t = 6.0$ s

4.6 $a = 1.5/25 = 0.06$ m s^{-2}

$F = 3 \times 0.06 = 0.18$ N in the direction of motion.

4.7 Resultant force = 10 N at an angle of $\tan^{-1}(3/4) = 37°$ with the direction of 8 N force. Acceleration = 2 m s^{-2} in the direction of the resultant force.

4.8 $a = -2.5$ m s^{-2}, Retarding force = 465 × 2.5 = 1.2 × 10^3 N

4.9 $F - 20{,}000 \times 10 = 20000 \times 5.0$, i.e., $F = 3.0 \times 10^5$ N

4.10 $a = -20$ m s^{-2} $0 \le t \le 30$ s

$t = -5$ s : $x = u\,t = -10 \times 5 = -50$ m

$t = 25$ s : $x = u\,t + (½)\ a\,t^2 = (10 \times 25 - 10 \times 625)$m $= -6$ km

$t = 100$ s : First consider motion up to 30 s

$x_1 = 10 \times 30 - 10 \times 900 = -8700$ m

At $t = 30$ s, $v = 10 - 20 \times 30 = -590$ m s^{-1}

For motion from 30 s to 100 s : $x_2 = -590 \times 70 = -41300$ m

$x = x_1 + x_2 = -50$ km

4.11 (a) Velocity of car (at $t = 10$ s) $= 0 + 2 \times 10 = 20$ m s^{-1}

By the First Law, the horizontal component of velocity is 20 m s^{-1} throughout.

Vertical component of velocity (at $t = 11$s) $= 0 + 10 \times 1 = 10$ m s^{-1}

Velocity of stone (at $t = 11$s) $= \sqrt{20^2 + 10^2} = \sqrt{500} = 22.4$ m s^{-1} at an angle of $\tan^{-1}$ (½) with the horizontal.

(b) 10 m s^{-2} vertically downwards.

4.12 (a) At the extreme position, the speed of the bob is zero. If the string is cut, it will fall vertically downwards.

(b) At the mean position, the bob has a horizontal velocity. If the string is cut, it will fall along a parabolic path.

4.13 The reading on the scale is a measure of the force on the floor by the man. By the Third Law, this is equal and opposite to the normal force N on the man by the floor.

(a) $N = 70 \times 10 = 700$ N ; Reading is 70 kg

(b) $70 \times 10 - N = 70 \times 5$; Reading is 35 kg

(c) $N - 70 \times 10 = 70 \times 5$; Reading is 105 kg

(d) $70 \times 10 - N = 70 \times 10$; Reading would be zero; the scale would read zero.

4.14 (a) In all the three intervals, acceleration and, therefore, force are zero.

(b) 3 kg m s^{-1} at $t = 0$; (c) -3 kg m s^{-1} at $t = 4$ s.

4.15 If the 20 kg mass is pulled,

$600 - T = 20\,a$, $T = 10\,a$

$a = 20$ m s^{-2}, $T = 200$ N

If the 10 kg mass is pulled, a = 20 m s^{-2}, $T = 400$ N

4.16 $T - 8 \times 10 = 8\,a$, $12 \times 10 - T = 12a$

i.e. $a = 2$ m s^{-2}, $T = 96$ N

4.17 By momentum conservation principle, total final momentum is zero. Two momentum vectors cannot sum to a null momentum unless they are equal and opposite.

4.18 Impulse on each ball = 0.05 ×12 = 0.6 kg m s^{-1} in magnitude. The two impulses are opposite in direction.

4.19 Use momentum conservation : $100\,v = 0.02 \times 80$

$v = 0.016$ m s^{-1} = 1.6 cm s^{-1}

4.20 Impulse is directed along the bisector of the initial and final directions. Its magnitude is $0.15 \times 2 \times 15 \times \cos 22.5° = 4.2$ kg m s^{-1}

4.21 $$v = 2\pi \times 1.5 \times \frac{40}{60} = 2\pi \text{ m s}^{-1}$$

$$T = \frac{mv^2}{R} = \frac{0.25 \times 4\pi^2}{1.5} = 6.6 \text{ N}$$

$$200 = \frac{mv_{max}^2}{R}, \text{which gives } v_{max} = 35 \text{ m s}^{-1}$$

4.22 Alternative (b) is correct, according to the First Law

4.23 (a) The horse-cart system has no external force in empty space. The mutual forces between the horse and the cart cancel (Third Law). On the ground, the contact force between the system and the ground (friction) causes their motion from rest.

(b) Due to inertia of the body not directly in contact with the seat.

(c) A lawn mower is pulled or pushed by applying force at an angle. When you push, the normal force (N) must be more than its weight, for equilibrium in the vertical direction. This results in greater friction f ($f \propto N$) and, therefore, a greater applied force to move. Just the opposite happens while pulling.

(d) To reduce the rate of change of momentum and hence to reduce the force necessary to stop the ball.

Chapter 5

5.1 (a) +ve (b) –ve (c) –ve (d) + ve (e) – ve

5.2 (a) 882 J ; (b) –247 J; (c) 635 J ; (d) 635 J;
Work done by the net force on a body equals change in its kinetic energy.

5.3 (a) $x > a$; 0 (c) $x < a$, $x > b$; $-V_1$
(b) $-\infty < x < \infty$; V_1 (d) $-b/2 < x < -a/2$, $a/2 < x < b/2$; $-V_1$

5.5 (a) rocket; (b) For a conservative force work done over a path is minus of change in potential energy. Over a complete orbit, there is no change in potential energy; (c) K.E. increases, but P.E. decreases, and the sum decreases due to dissipation against friction; (d) in the second case.

5.6 (a) decrease; (b) kinetic energy; (c) external force; (d) total linear momentum, and also total energy (if the system of two bodies is isolated).

5.7 (a) F ; (b) F ; (c) F ; (d) F (true usually but not always, why?)

5.8 (a) No
(b) Yes
(c) Linear momentum is conserved during an inelastic collision, kinetic energy is, of course, not conserved even after the collision is over.
(d) elastic.

5.9 (b) t

5.10 (c) $t^{3/2}$

5.11 12 J

5.12 The electron is faster, $v_e / v_p = 13.5$

5.13 0.082 J in each half ; – 0.163 J

5.14 Yes, momentum of the molecule + wall system is conserved. The wall has a recoil momentum such that the momentum of the wall + momentum of the outgoing molecule equals momentum of the incoming molecule, assuming the wall to be stationary initially. However, the recoil momentum produces negligible velocity because of the large mass of the wall. Since kinetic energy is also conserved, the collision is elastic.

5.15 43.6 kW

5.16 (b)

5.17 It transfers its entire momentum to the ball on the table, and does not rise at all.

5.18 5.3 m s^{-1}

5.19 27 km h^{-1} (no change in speed)

5.20 50 J

5.21 (a) $m = \rho A v t$ (b) $K = \rho A v^3 t / 2$ (c) $P = 4.5$ kW

5.22 (a) 49,000 J (b) 6.45 10^{-3} kg

5.23 (a) 200 m^2 (b) comparable to the roof of a large house of dimension 14m 14m.

Chapter 6

6.1 The geometrical centre of each. No, the CM may lie outside the body, as in case of a ring, a hollow sphere, a hollow cylinder, a hollow cube etc.

6.2 Located on the line joining H and C1 nuclei at a distance of 1.24 Å from the H end.

6.3 The speed of the CM of the (trolley + child) system remains unchanged (equal to *v*) because no external force acts on the system. The forces involved in running on the trolley are internal to this system.

6.6 $l_z = xp_y - yp_x$, $l_x = yp_z - zp_y$, $l_y = zp_x - xp_z$

6.8 72 cm

6.9 3675 N on each front wheel, 5145 N on each back wheel.

6.10 Sphere

6.11 Kinetic Energy = 3125 J; Angular Momentum = 62.5 J s

6.12 (a) 100 rev/min (use angular momentum conservation).

(b) The new kinetic energy is 2.5 times the initial kinetic energy of rotation. The child uses his internal energy to increase his rotational kinetic energy.

6.13 25 s^{-2}; 10 m s^{-2}

6.14 36 kW

6.15 at R/6 from the center of original disc opposite to the center of cut portion.

6.16 66.0 g

6.17 6.75 10^{12} rad s^{-1}

Chapter 7

7.1 (a) No.
(b) Yes, if the size of the space ship is large enough for him to detect the variation in g.
(c) Tidal effect depends inversely on the cube of the distance unlike force, which depends inversely on the square of the distance.

7.2 (a) decreases; (b) decreases; (c) mass of the body; (d) more.

7.3 Smaller by a factor of 0.63.

7.5 3.54 10^8 years.

7.6 (a) Kinetic energy, (b) less,

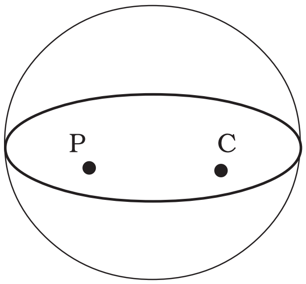
7.7 (a) No, (b) No, (c) No, (d) Yes

[The escape velocity is independent of mass of the body and the direction of projection. It depends upon the gravitational potential at the point from where the body is launched. Since this potential depends (slightly) on the latitude and height of the point, the escape velocity (speed) depends (slightly) on these factors.]

7.8 All quantities vary over an orbit except angular momentum and total energy.

7.9 (b), (c) and (d)

7.10 and **7.11** For these two problems, complete the hemisphere to sphere. At both P, and C, potential is constant and hence intensity = 0. Therefore, for the hemisphere, (c) and (e) are correct.



7.12 2.6×10^8 m

7.13 2.0×10^{30} kg

7.14 1.43×10^{12} m

7.15 28 N

7.16 125 N

7.17 8.0×10^6 m from the earth's centre

7.18 31.7 km/s

7.19 5.9×10^9 J

7.20 2.6×10^6 m/s

7.21 0, 2.7×10^{-8} J/kg; an object placed at the mid point is in an unstable equilibrium

Notes

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