Year 11 Physics

Term1 Week 9 Review Test

Q1

A golf ball rolls up a hill toward a miniature-golf hole. Assume that the direction toward the hole is positive.

a. If the golf ball starts with a speed of 2.0 m/s and slows at a constant rate of 0.50 m/s^2, what is its velocity after 2.0 s?

$$v = u + at$$
$$= 2.0\ m/s + (-0.50\ m/s^2)(2.0\ s)$$
$$= 1.0\ m/s$$

b. What is the golf ball's velocity if the constant acceleration continues for 6.0 s?

$$v = u + at$$
$$= 2.0\ m/s + (-0.50\ m/s^2)(6.0\ s)$$
$$= -1.0\ m/s$$

Q2

A bus that is traveling at 30.0 km/h speeds up at a constant rate of 3.5 m/s^2. What velocity does it reach 6.8 s later?

$$\mathbf{v} = \mathbf{u} + \boldsymbol{a}t$$

$$= 30.0 \text{ km/h} + (3.5 \text{ m/s}^2)(6.8 \text{ s})\left(\frac{1 \text{ km}}{1000 \text{ m}}\right)\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)$$

$$= 120 \text{ km/h}$$

Q3

If a car accelerates from rest at a constant 5.5 m/s^2, how long will it take for the car to reach a velocity of 28 m/s?

$$v = u + at$$

$$\text{so } t = \frac{v_f - v_i}{a}$$

$$= \frac{28 \text{ m/s} - 0.0 \text{ m/s}}{5.5 \text{ m/s}^2}$$

$$= 5.1 \text{ s}$$

Q4

A car slows from 22 m/s to 3.0 m/s at a constant rate of 2.1 m/s^2. How many seconds are required before the car is traveling at 3.0 m/s?

$$v = u + at$$

$$\text{so } t = \frac{v_f - v_i}{a}$$

$$= \frac{3.0 \text{ m/s} - 22 \text{ m/s}}{-2.1 \text{ m/s}^2}$$

$$= 9.0 \text{ s}$$

Q5

A race car travels on a racetrack at 44 m/s and slows at a constant rate to a velocity of 22 m/s over 11 s. How far does it move during this time?

$$\bar{v} = \frac{\Delta v}{2} = \frac{(v_f - u)}{2}$$

$$\Delta d = \bar{v}\Delta t$$

$$= \frac{(v_f - u\ \Delta t}{2}$$

$$= \frac{(22\ \text{m/s} - 44\ \text{m/s})(11\ \text{s})}{2}$$

$$= -1.2 \times 10^2\ \text{m}$$

Q6

- A woman driving at a speed of 23 m/s sees a deer on the road ahead and applies the brakes when she is 210 m from the deer. If the deer does not move and the car stops right before it hits the deer, what is the acceleration provided by the car's brakes?

$$v_f^2 = u^2 + 2a(d_f - d_i)$$

$$a = \frac{v_f^2 - u^2}{2(d_f - d_i)}$$

$$= \frac{0.0 \text{ m/s} - (23 \text{ m/s})^2}{(2)(210 \text{ m})}$$

$$= -1.3 \text{ m/s}^2$$

Q7

Final Velocity An airplane accelerated uniformly from rest at the rate of 5.0 m/s^2 for 14 s. What final velocity did it attain?

$$v_f = u + at_f$$

$$= 0 + (5.0\ m/s^2)(14\ s) = 7.0\times10^1\ m/s$$

Q8

- A construction worker accidentally drops a brick from a high scaffold.
- **a.** What is the velocity of the brick after 4.0 s?

Say upward is the positive direction.

$v_f = u + at,\ a = -g = -9.80\ \text{m/s}^2$

$v_f = 0.0\ \text{m/s} + (-9.80\ \text{m/s}^2)(4.0\ \text{s})$

$= -39\ \text{m/s}$ when the upward direction is positive

- **b.** How far does the brick fall during this time?

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

$$= 0 + \left(\frac{1}{2}\right)(-9.80\ \text{m/s}^2)(4.0\ \text{s})^2$$

$$= -78\ \text{m}$$

The brick falls 78 m.

Q9

- A student drops a ball from a window 3.5 m above the sidewalk. How fast is it moving when it hits the sidewalk?

$$v_f^2 = u^2 + 2ad,\ a = g \text{ and } v_i = 0$$

$$\text{so } v_f = \sqrt{2gd}$$

$$= \sqrt{(2)(9.80\ \text{m/s}^2)(3.5\ \text{m})}$$

$$= 8.3\ \text{m/s}$$

Q10

- The driver of a car going 90.0 km/h suddenly sees the lights of a barrier 40.0 m ahead. It takes the driver 0.75 s to apply the brakes, and the average acceleration during braking is 10.0 m/s^2.
- **a.** Determine whether the car hits the barrier.

The car will travel

$d = vt = (25.0 \text{ m/s})(0.75 \text{ s})$

$= 18.8$ m (Round off at the end.)

before the driver applies the brakes.

Convert km/h to m/s.

$$u = \frac{(90.0 \text{ km/h})(1000 \text{ m/km})}{3600 \text{ s/h}}$$

$$= 25.0 \text{ m/s}$$

$$v_f^2 = u_i^2 + 2a(d_f - d_i)$$

$$d_f = \frac{v_f^2 - u^2}{2a} + d_i$$

$$= \frac{(0.0 \text{ m/s})^2 - (25.0 \text{ m/s})^2}{(2)(-10.0 \text{ m/s}^2)} + 18.8 \text{ m}$$

$= 5.0\times10^1$ m, yes it hits the barrier

Q11

The driver of a vehicle travelling at 8m s- 1 applies the brakes for 30 s and reduces the velocity of the vehicle to 2m s- 1• Calculate the deceleration of the vehicle during this time.

$$u = 8\,\mathrm{m\,s^{-1}},\ v = 2\,\mathrm{m\,s^{-1}},\ t = 30\,\mathrm{s}$$

$$a = \frac{v - u}{t} = \frac{2 - 8}{30} = \frac{-6}{30} = -0.2\,\mathrm{m\,s^{-2}}$$

Q12

- Two horizontal forces, 225 N and 165 N, are exerted on a canoe. If these forces are applied in the same direction, find the net horizontal force on the canoe.

$$F_{net} = 225\text{ N} + 165\text{ N} = 3.90\times10^{2}\text{ N}$$

in the direction of the two forces

Q13

- What is the net force acting on a 1.0-kg ball in free-fall?

$$F_{net} = F_g = mg$$

$$= (1.0\ \text{kg})(9.80\ \text{m/s}^2)$$

$$= 9.8\ \text{N}$$

Q14

A car of mass 2300 kg slows down at a rate of 3.0 m/s^2 when approaching a stop sign. What is the magnitude of the net force causing it to slow down?

$$F = ma$$

$$= (2300\ \text{kg})(3.0\ \text{m/s}^2)$$

$$= 6.9 \times 10^3\ \text{N}$$

Q15

A grocery sack can withstand a maximum of 230 N before it rips. Will a bag holding 15 kg of groceries that is lifted from the checkout counter at an acceleration of 7.0 m/s^2 hold?

Use Newton's second law $F_{net} = ma$.

If $F_{groceries} > 230$, then the bag rips.

$$F_{groceries} = m_{groceries}a_{groceries} + m_{groceries}g$$

$$= m_{groceries}(a_{groceries} + g)$$

$$= (15\ \text{kg})(7.0\ \text{m/s}^2 + 9.80\ \text{m/s}^2)$$

$$= 250\ \text{N}$$

The bag does not hold.

Q16

A space vehicle moving towards a docking station at a velocity of 2.5 ms-1 is 26m from the docking station when its reverse thrust motors are switched on to slow it down and stop it when it reaches the station. The vehicle decelerates uniformly until it comes to rest at the docking station when its motors arc switched off.

Calculate a) its deceleration, b) how long it takes to stop.

Let the + direction represent motion towards the docking station and – represent motion away from the station.

Initial velocity $u = +2.5\,\mathrm{m\,s^{-1}}$, final velocity $v = 0$, displacement $s = +26\,\mathrm{m}$.

a To find its deceleration, a, use $v^2 = u^2 + 2as$

$$0 = 2.5^2 + 2a \times 26 \qquad \text{so } -52a = 2.5^2$$

$$a = \frac{2.5^2}{52} = -0.12\,\mathrm{m\,s^{-2}}$$

b To find the time taken, use $v = u + at$

$$0 = 2.5 - 0.12t \qquad \text{so } 0.12t = 2.5$$

$$t = \frac{2.5}{0.12} = 21\,\mathrm{s}$$

Q17

A driver of a vehicle travelling at a speed of 30 m s- on a freeway brakes sharply to a standstill in a distance of 100 m. Calculate the deceleration of the vehicle.

$u = 30\,\mathrm{m\,s^{-1}}$, $v = 0$, $s = 100$ m, $a = ?$

To find a, use $v^2 = u^2 + 2as$

Therefore $0 = u^2 + 2as$ because $v = 0$

Rearranging this equation gives

$2as = -u^2$

$$a = -\frac{u^2}{2s} = -\frac{30^2}{2 \times 100} = -4.5\,\mathrm{m\,s^{-2}}$$

Q18

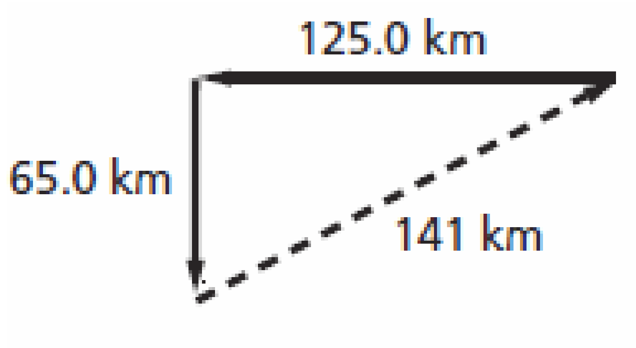
- A car is driven 125.0 km due west, then 65.0 km due south. What is the magnitude of its displacement?

$$R^2 = A^2 + B^2$$

$$R = \sqrt{A^2 + B^2}$$

$$= \sqrt{(65.0\ \text{km})^2 + (125.0\ \text{km})^2}$$

$$= 141\ \text{km}$$



Q19

- You walk 30 m south and 30 m east. Find the magnitude and direction of the resultant displacement

$$R^2 = A^2 + B^2$$

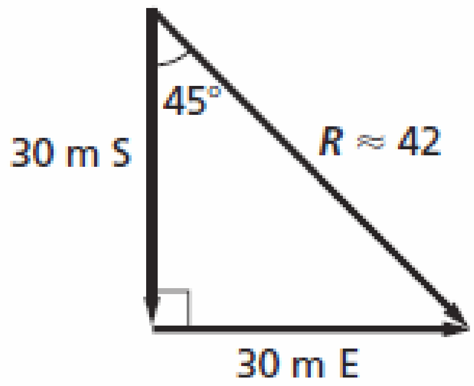
$$R = \sqrt{(30\text{ m})^2 + (30\text{ m})^2}$$

$$= 40\text{ m}$$

$$\tan\theta = \frac{30\text{ m}}{30\text{ m}} = 1$$

$$\theta = 45°$$

$$R = 40\text{ m, } 45° \text{ east of south}$$



Q20

- A force of 40.0 N accelerates a 5.0-kg block at 6.0 $m/s^2$2 along a horizontal surface. How large is the frictional force?

$$ma = F_{net} = F_{appl} - F_f$$

$$\text{so } F_f = F_{appl} - ma$$

$$= 40.0\ \text{N} - (5.0\ \text{kg})(6.0\ \text{m/s}^2)$$

$$= 1.0 \times 10^1\ \text{N}$$

Q20

A coin was released at rest at the top of a well. It took l.6s to hit the bottom of the well. Assuming air resistance is negligible calculate a) the distance fallen by the coin, b its speed just before impact.

$u = 0$, $t = 1.6$ s, $a = -9.8\,\mathrm{m\,s^{-2}}$ (– as g acts downwards)

a To find s, use $s = \frac{1}{2}at^2$ as $u = 0$

Therefore $s = \frac{1}{2} \times -9.8 \times 1.6^2$

$= -12.5\,\mathrm{m}$ (– indicates 12.5 m downwards)

b To find v, use $v = u + at$

$= 0 + (-9.8 \times 1.6) = -15.7\,\mathrm{m\,s^{-1}}$ (– indicates downward velocity)

Q21

- A compact car, with mass 725 kg, is moving at 115 km/h toward the east. Sketch the moving car.
- Find the magnitude and direction of its momentum.

$$p = mv$$
$$= (725\text{ kg})(115\text{ km/h})\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)$$
$$= 2.32\times10^{4}\text{ kg·m/s eastward}$$

- A second car, with a mass of 2175 kg, has the same momentum. What is its velocity?

$$v = \frac{p}{m}$$
$$= \frac{(2.32\times10^{4}\text{ kg·m/s})\left(\frac{3600\text{ s}}{1\text{ h}}\right)\left(\frac{1\text{ km}}{1000\text{ m}}\right)}{2175\text{ kg}}$$
$$= 38.4\text{ km/h eastward}$$

Q22

- A 0.174-kg softball is pitched horizontally at 26.0 m/s. The ball moves in the opposite direction at 38.0 m/s after it is hit by the bat.
- What is the change in momentum of the ball?

$$\Delta p = m(v_f - v_i)$$
$$= (0.174\ \text{kg})(38.0\ \text{m/s} - (-26.0\ \text{m/s}))$$
$$= 11.1\ \text{kg·m/s}$$

- What is the impulse delivered by the bat?

$$F\Delta t = p_f - p_i$$
$$= \Delta p$$
$$= 11.1\ \text{kg·m/s}$$
$$= 11.1\ \text{N·s}$$

Q23

- Two goods wagons cars, each with a mass of 3.0105 kg, collide and stick together. One was initially moving at 2.2 m/s, and the other was at rest. What is their final speed?

$$p_i = p_f$$

$$mv_{Ai} + mv_{Bi} = 2mv_f$$

$$v_f = \frac{v_{Ai} + v_{Bi}}{2}$$

$$= \frac{2.2 \text{ m/s} + 0.0 \text{ m/s}}{2}$$

$$= 1.1 \text{ m/s}$$

Q24

- In a ballistics test at the police department, Officer Dafney fires a 6.0-g bullet at 350 m/s into a container that stops it in 1.8 ms. What is the average force that stops the bullet?

$$F = \frac{\Delta p}{\Delta t}$$

$$= \frac{m(v_f - v_i)}{\Delta t}$$

$$= \frac{(0.0060\ \text{kg})(0.0\ \text{m/s} - 350\ \text{m/s})}{1.8 \times 10^{-3}\ \text{s}}$$

$$= -1.2 \times 10^{3}\ \text{N}$$

Q25

- A 95-kg fullback, running at 8.2 m/s, collides in mid-air with a 128-kg defensive tackle moving in the opposite direction. Both players end up with zero speed.

Before: $m_{FB} = 95$ kg

$v_{FB} = 8.2$ m/s

$m_{DT} = 128$ kg

$v_{DT} = ?$

After: $m = 223$ kg

$v_f = 0$ m/s

What was the fullback's momentum before the collision?

$$p_{FB} = m_{FB}v_{FB} = (95 \text{ kg})(8.2 \text{ m/s})$$
$$= 7.8\times10^2 \text{ kg}\cdot\text{m/s}$$

What was the change in the fullback's momentum?

$$\Delta p_{FB} = p_f - p_{FB}$$
$$= 0 - p_{FB} = -7.8\times10^2 \text{ kg}\cdot\text{m/s}$$

Q26

- A constant force of 6.00 N acts on a 3.00-kg object for 10.0 s. What are the changes in the object's momentum and velocity?

The change in momentum is

$$\Delta p = F\Delta t$$

$$= (6.00\ \text{N})(10.0\ \text{s})$$

$$= 60.0\ \text{N·s} = 60.0\ \text{kg·m/s}$$

The change in velocity is found from the impulse.

$$F\Delta t = m\Delta v$$

$$\Delta v = \frac{F\Delta t}{m}$$

$$= \frac{(6.00\ \text{N})(10.0\ \text{s})}{3.00\ \text{kg}}$$

$$= 20.0\ \text{m/s}$$

Q27

- A box that weighs 575 N is lifted a distance of 20.0 m straight up by a cable attached to a motor. The job is done in 10.0 s. What power is developed by the motor in W and kW?

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(575\ \text{N})(20.0\ \text{m})}{10.0\ \text{s}}$$

$$= 1.15\times10^{3}\ \text{W} = 1.15\ \text{kW}$$

Q28

- A forklift raises a box 1.2 m and does 7.0 kJ of work on it. What is the mass of the box?

$$W = Fd = mgd$$

$$\text{so } m = \frac{W}{gd} = \frac{7.0\times10^3\ \text{J}}{(9.80\ \text{m/s}^2)(1.2\ \text{m})}$$

$$= 6.0\times10^2\ \text{kg}$$

Q29

- A force of 300.0 N is used to push a 145-kg mass 30.0 m horizontally in 3.00 s.
- **a.** Calculate the work done on the mass.

$$W = Fd = (300.0\ \text{N})(30.0\ \text{m})$$
$$= 9.00\times10^{3}\ \text{J}$$
$$= 9.00\ \text{kJ}$$

- **b.** Calculate the power developed.

$$P = \frac{W}{t} = \frac{9.00\times10^{3}\ \text{J}}{3.00\ \text{s}}$$
$$= 3.00\times10^{3}\ \text{W}$$
$$= 3.00\ \text{kW}$$

Q30

- A boy lifts a 2.2-kg book from his desk, which is 0.80 m high, to a bookshelf that is 2.10 m high. What is the potential energy of the book relative to the desk?

$$
\begin{aligned}
PE &= mg(h_f - h_i) \\
&= (2.2\ \text{kg})(9.80\ \text{m/s}^2)(2.10\ \text{m} - 0.80\ \text{m}) \\
&= 28\ \text{J}
\end{aligned}
$$

Q31

(a) A cricketer throws a ball vertically upwards so that the ball leaves his hands at a speed of $25\,\text{m s}^{-1}$. If air resistance can be neglected, calculate

(i) the maximum height reached by the ball,

(a)(i) (use of $v^2 = u^2 + 2as$ gives) $0 = 25^2 - 2 \times 9.81 \times s$

$19.6\,s = 625$ and $s = 32\,\text{m}$

(ii) the time taken to reach maximum height,

$$t = \frac{25}{9.81} = 2.5\ \text{s}$$

(iii) the speed of the ball when it is at 50% of the maximum height.

(iii) (use of $v^2 = u^2 + 2as$ gives) $v^2 = 25^2 - 2 \times 9.81 \times 16$

(allow C.E. from (a)(i))

and $v = 18\,\text{m s}^{-1}$

Q31 continued

(b) When catching the ball, the cricketer moves his hands for a short distance in the direction of travel of the ball as it makes contact with his hands. Explain why this technique results in less force being exerted on the cricketer's hands.

(b) time to stop the ball is greater ✓
∴ rate of change of momentum is less ✓
[or work done on ball is the same but greater distance ✓ ∴ less force ✓]

Q32

A car accelerates at a steady rate of $2.5\,m\,s^{-2}$ along a straight, level road. The mass of the car is $1.3 \times 10^3\,kg$.

(a) Calculate the magnitude of the resultant force acting on the car.

(a) (use of $F = ma$ gives) $F = 1.3 \times 10^3 \times 2.5$ ✓

$= 3250\,N$ ✓(3.25×10^3)

(b) When the accelerating car reaches a speed of $2.2\,m\,s^{-1}$, the total force opposing the motion of the car is 410 N.

(b)(i) driving force = 3250 + 410 = 3660 N

(ii) the power delivered to the wheels of the car.

(use of $P = Fv$ gives) $P = 3660 \times 2.2$

$= 8100\,W$ ✓ (8.1×10^3)

Q33

A girl kicks a ball along the ground at a wall 2.0 m away. The ball strikes the wall normally at a velocity of $8.0\,m\,s^{-1}$ and rebounds in the opposite direction with an initial velocity of $6.0\,m\,s^{-1}$. The girl, who has not moved, stops the ball a short time later.

(a) Explain why the final displacement of the ball is not 4.0 m.

displacement is a vector ✓
ball travels in opposite directions ✓

(b) Explain why the average velocity of the ball is different from its average speed.

(b) velocity is rate of change of displacement
average speed is rate of change of distance
velocity is a vector [or speed is a scalar]
velocity changes direction

Q33 continued

(c) The ball has a mass of 0.45 kg and is in contact with the wall for 0.10 s. For the period of time the ball is in contact with the wall,

(i) calculate the average acceleration of the ball.

$$a = \frac{(-6.0 - 8.0)}{0.10}$$
$$= (-)140.\text{m s}^{-1}$$

(ii) calculate the average force acting on the ball.

$$F = 0.45 \times (-)140 = (-)63\ \text{N}$$

(iii) state the direction of the average force acting on the ball.

away from wall ✓
at right angles to wall ✓
[or back to girl ✓ ✓]
[or opposite to direction of velocity at impact ✓ ✓]

Q34

A constant resultant horizontal force of 1.8×10^3 N acts on a car of mass 900 kg, initially at rest on a level road.

(a) Calculate

(i) the acceleration of the car,

(use of $F = ma$ gives) $1.8 \times 10^3 = 900\,a$

$a = 2.0\ \text{m s}^{-2}$ ✓

(ii) the speed of the car after 8.0 s,

(use of $v = u + at$ gives) $v = 2.0 \times 8.0 = 16\ \text{m s}^{-1}$

Q34 continued

(iii) the momentum of the car after 8.0 s,

(use of $p = mv$ gives) $p = 900 \times 16$

$= 14 \times 10^3$ kg m s^{-1} (or N s)

(iv) the distance travelled by the car in the first 8.0 s of its motion,

(use of $s - ut + ½at^2$ gives) $s - \frac{1}{2} \times 2.0 \times 8^2 = 64$ m

(v) the work done by the resultant horizontal force during the first 8.0 s.

(use of $W = Fs$ gives) $W = 1.8 \times 10^3 \times 64$

$= 1.2 \times 10^5$ J

Q35

A ball is released from a height of 0.85 m above a bed of sand, and creates an impression in the sand of depth 0.025 m. For directions, let + represent upwards and - represent downwards

Stage 1: $u = 0$, $s = -0.85\,\text{m}$, $a = -9.8\,\text{m}\,\text{s}^{-2}$.

To calculate the speed of impact v, use $v^2 = u^2 + 2as$

$$v^2 = 0^2 + 2 \times -9.8 \times -0.85 = 16.7\,\text{m}^2\text{s}^{-2} \qquad v = -4.1\,\text{m}\,\text{s}^{-1}$$

Note:
$v^2 = 16.7\,\text{m}^2\text{s}^{-2}$ so $v = -4.1$ or $+4.1\,\text{m}\,\text{s}^{-1}$. The negative answer is chosen as the ball is moving downwards.

Stage 2: $u = -4.1\,\text{m}\,\text{s}^{-1}$, $v = 0$ (as the ball comes to rest in the sand), $s = -0.025\,\text{m}$

To calculate the deceleration, a, use $v^2 = u^2 + 2as$

$$0^2 = (-4.1)^2 + 2a \times -0.025$$

$$2a \times 0.025 = 16.8$$

$$a = \frac{16.8}{2 \times 0.025} = 336\,\text{m}\,\text{s}^{-2}$$

Q36

A vehicle of mass 900kg, travelling on a level road at a speed of I 5 m s-1, can be brought to a standstill without skidding by a braking force equal to 0.5 x its weight. Calculate a the deceleration of the vehicle, b the braking distance.

a Weight = $900 \times 9.8 = 8800\,\text{N}$

Braking force = $0.5 \times 8800 = 4400\,\text{N}$

$$\text{Deceleration} = \frac{\text{braking force}}{\text{mass}} = \frac{4400}{900} = 4.9\,\text{m}\,\text{s}^{-2}$$

b $u = 15\,\text{m}\,\text{s}^{-1}$, $v = 0$, $a = -4.9\,\text{m}\,\text{s}^{-2}$

To calculate s, use $v^2 = u^2 + 2as$

$$s = \frac{-u^2}{2a} = \frac{-15^2}{2 \times -4.9} = 23\,\text{m}$$

Q37

A ball of mass 0.63kg initially at rest was struck by a bat which gave it a velocity of 35 ms-1• The contact time between the bat and ball was 25 ms. Calculate:
a the momentum gained by the ball b the average force of impact on the ball.

a Momentum gained = $0.63 \times 35 = 22\,\text{kg}\,\text{m}\,\text{s}^{-1}$

b Impact force $= \dfrac{\text{gain of momentum}}{\text{contact time}} = \dfrac{22}{0.025} = 880\,\text{N}$

Q38

A tennis ball of mass 0.20 kg moving at a speed of 18m s- 1 was hit by a bat, causing the ball to go back in the direction it came from at a speed of l 5ms-1• The contact time was O. I 2s. Calculate:

a) the change of momentum of the ball b) the impact force on the ball.

a Mass of ball $m = 0.20\,\text{kg}$, initial velocity $u = +18\,\text{m}\,\text{s}^{-1}$, final velocity $= -15\,\text{m}\,\text{s}^{-1}$.

Change of momentum $= mv - mu = (0.20 \times -15) - (0.20 \times 18)$
$= -3.0 - 3.6 = -6.6\,\text{kg}\,\text{m}\,\text{s}^{-1}$

b Impact force $= \dfrac{\text{change of momentum}}{\text{time taken}} = \dfrac{-6.6}{0.12} = -55\,\text{N}$

Note: The minus sign indicates the force on the ball is in the same direction as the velocity after the impact.

Q39

A rail wagon C of mass 4500 kg moving along a level track at a speed of 3.0 ms 1 collides with and couples to a second rail wagon D of mass 3000 kg which is initially stationary. Calculate the speed of the two wagons immediately after the collision.

Total initial momentum = initial momentum of C + initial momentum of D

$= (4500 \times 3.0) + (3000 \times 0) = 13\,500\,\text{kg}\,\text{m}\,\text{s}^{-1}$

Total final momentum = total mass of C and D × velocity v after the collision

$= (4500 + 3000)\,v = 7500\,v$

Using the principle of conservation of momentum,

$$7500\,v = 13\,500$$

$$v = \frac{13\,500}{7500} = 1.8\,\text{m}\,\text{s}^{-1}$$

Q40

A railway wagon of mass 8000kg moving at 3.0ms 1 collides with an initially stationary wagon of mass 5000 kg. The two wagons separate after the collision. The 8000 kg wagon moves at a speed of I .Om s- 1 without change of direction after the collision. Calculate: a) the speed and direction of the 5000 kg wagon after the collision b) the loss of kinetic energy due to the collision.

a The total initial momentum = $8000 \times 3 = 24\,000\,\text{kg}\,\text{m}\,\text{s}^{-1}$.

The total final momentum = $(8000 \times 1.0) + 5000V$, where V is the speed of the 5000 kg wagon after the collision.

Using the principle of conservation of momentum

$$8000 + 5000V = 24\,000$$

$$5000V = 24\,000 - 8000 = 16\,000$$

$$V = \frac{16\,000}{5000} = 3.2\,\text{m}\,\text{s}^{-1}$$

b Kinetic energy of the 8000 kg wagon before the collision

$$= \frac{1}{2} \times 8000 \times 3.0^2 = 36\,000\,\text{J}$$

Kinetic energy of the 8000 kg wagon after the collision

$$= \frac{1}{2} \times 8000 \times 1.0^2 = 4000\,\text{J}$$

Kinetic energy of the 5000 kg wagon after the collision

$$= \frac{1}{2} \times 5000 \times 3.2^2 = 25\,600\,\text{J}$$

∴ loss of kinetic energy due to the collision

$$= 36\,000 - (4000 + 25\,600)$$
$$= 6400\,\text{J}$$

Q41

On a fairground ride, the track descends by a vertical drop of 55m over a distance of 120m along the track. A train of mass 2500 kg on the track reaches a speed of 30 m s- 1 at the bottom of the descent after being at rest at the top. Calculate a) the loss of potential energy of the train, b) its gain of kinetic energy, c) the average frictional force on the train during the descent.

a Loss of potential energy $= mg\Delta h = 2500 \times 9.8 \times 55 = 1.35 \times 10^6\,\text{J}$

b Its gain of kinetic energy $= \frac{1}{2}mv^2 = 0.5 \times 2500 \times 30^2$

$= 1.13 \times 10^6\,\text{J}$

c Work done to overcome friction $= mg\Delta h - \frac{1}{2}mv^2$

$= 1.35 \times 10^6 - 1.13 \times 10^6$

$= 2.2 \times 10^5\,\text{J}$

Because the work done to overcome friction = frictional force × distance moved along track,

$$\text{the frictional force} = \frac{\text{work done to overcome friction}}{\text{distance moved}}$$

$$= \frac{2.2 \times 10^5}{120} = 1830\,\text{N}$$

Q42

A fairground ride ends with a car moving up a ramp at a slope of 30° to the horizontal.

(a) The car and its passengers have a total weight of 7 .2 x 10 3 N. Show that the component of the weight parallel to the ramp is 3.6 x 103 N.
(b) Calculate the deceleration of the car assuming the only force causing the car to decelerate is that calculated in part (a).
(c) The car enters at the bottom of the ramp at 18ms-1• Calculate the minimum length of the ramp for the car to stop before it reaches the end. The length of the car should be neglected.
(d) Explain why the stopping distance is, in practice, shorter than the value calculated in part (c).

Q42 continued

(a) component of weight parallel to ramp
$= W \sin\theta = 7.2 \times 10^3 \sin 30°$
$= 3.6 \times 10^3$ N

(b) mass of car and passengers
$$M = \frac{W}{g} = \frac{7.2 \times 10^3}{9.81} = 734 \text{ kg}$$
use of $F = ma$ gives deceleration
$$a = \frac{F}{m} = \frac{3.6 \times 10^3}{734} = 4.90 \text{ m s}^{-2}$$

(c) use of $v^2 = u^2 + 2as$ gives
$0 = 18^2 + (-2 \times 4.90 \times s)$
$\therefore$ length of ramp $s = 33$ m

(d) *Relevant points include*:
- frictional forces act on car and passengers
- these increase the resultant force acting down the ramp
- therefore the deceleration is greater
- energy is lost as heat