Linear Motion & Force

Formulae:

Where:

s = Displacement (m)

u = Initial velocity (ms^{-1})

v = Velocity (ms^{-1})

t = Time (s)

a = Acceleration (ms^{-2})

Note: g = acceleration of freefalling objects = 9.8 ms^{-2}

p = Momentum ($kgms^{-1}$)

F = Force (N)

P = Power (W)

$$a=\frac{v-u}{t}$$

$$v=u+at$$

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

$$v^2=u^2+2as$$

$$p=mv$$

$$F = ma = \frac{\Delta p}{t} = \frac{p_f-p_i}{t} = \frac{m(v-u)}{t}$$

$$Impulse=F_{net}t=\Delta p=m(v-u)$$

$$P = \frac{W}{t} = \frac{\Delta E}{t} = \frac{\Delta E_k}{t} = \frac{\frac{1}{2}xmv^2-\frac{1}{2}xmu^2}{t} = \frac{\Delta E_p}{t} = \frac{mgh_f-mgh_i}{t} = \frac{Fs}{t} = Fv_c$$

$W = Fs \times \cos\theta$

Law of conservation of momentum:

$\sum p_i = \sum p_f$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$\sum F = W + F_N \rightarrow F_N = \sum F - W = ma - mg = m(a - g)$

$a = \frac{v-u}{t}$ no ‘s’

$s = ut + \frac{1}{2}at^2$ no ‘v’

$v^2 = u^2 + 2as$ no ‘t’

Elevator questions: $\sum F = F_{normal} + W$

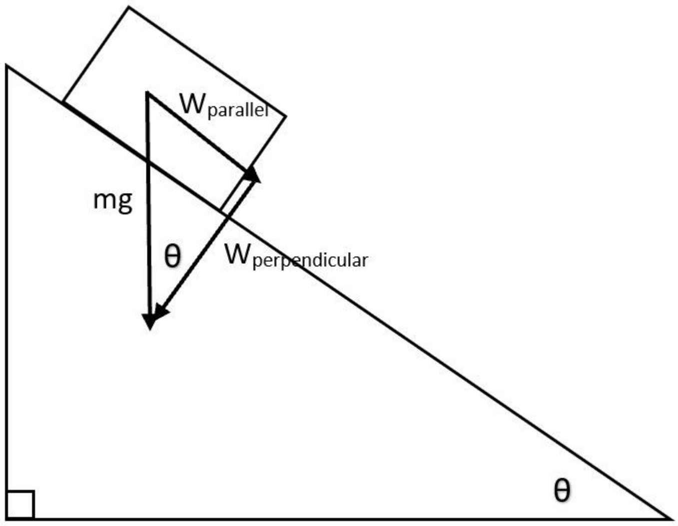
Tension questions: $\sum F = F_{tension} + W$

Driving force questions: $\sum F = F_{engine} + F_{friction}$

For inclined plane questions:

$\sum F = mg \sin\theta$

$F_{normal} = mg \cos\theta$

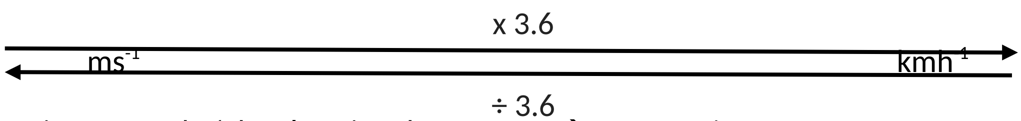


Accelerating upwards / decelerating downwards → positive value for ‘a’.

Decelerating upwards / accelerating downwards → negative value for ‘a’.

‘g’ is always negative.

∑F = weight force + normal force (normal force = ∑F – W)



Accelerating upwards / decelerating downwards → Increase in apparent mass.

Increased apparent mass → feeling heavier → the normal force exceeds the weight force.

Accelerating downwards / decelerating upwards → Decrease in apparent mass.

Decreased apparent mass → feeling lighter → the normal force is less than the weight force.

Gain in kinetic energy = loss of potential energy.

Gain in potential energy = loss of kinetic energy.

Frictional force = Initial potential energy – final kinetic energy.

Pressure $\propto \frac{1}{Surface\ area}$ – smaller surface area creates greater pressure.

A sailor rowed out from the shore in his dinghy at a constant acceleration of 0.11 ms^{-2} until he reached a speed of 1.70 ms^{-1}. He continued at this speed until he arrived at his yacht, anchored 30m offshore. Calculate how long his trip took.

a = $\frac{\Delta v}{t}$ → 0.11 = $\frac{1.7}{t}$ → t = 15.45s

s = $\frac{1}{2}$ x 0.11 x 15.45^2 = 13.14m

t = $\frac{s}{v}$ = $\frac{30-13.14}{1.7}$ = 9.12s

t = 15.45 + 9.12 = 25.4s

Q: When Jane calculated her average velocity for the trip, she found it was 20km/h less than her average speed. Explain.

The road between the two towns is not a straight line. Jane's velocity would be calculated using the vector drawn between the two towns (Jane's displacement) rather than the total distance travelled. As this vector is smaller than the total distance she travelled, her velocity will be less.

Q: Describe how you'd check the accuracy of your speedometer.

Drive a fixed distance while keeping the speedometer reading a constant speed. By timing how long it takes you to drive this distance you can determine your actual speed and compare this to the value given by the speedometer.

Q: You can estimate the depth of a well with a stopwatch and a stone. Why's this only an estimation?

The calculated value will likely be smaller than the actual depth. This is because air resistance isn't considered and will slow the acceleration of the stone a little.

Q: Why's the speed limit in areas around schools reduced by 10km/h during certain times in the morning and afternoon of school days?

By reducing the speed limit, the stopping distance of drivers in these areas is significantly decreased, reducing the likelihood of an injury.

Q: Explain why the gardener and barrow will move.

~~It is true that the forces between the gardener and then barrow are equal and opposite where they are in contact on the handles but the force of the ground on the feet of the gardener is greater than the force of the ground on the wheel of the barrow in the opposite direction so they move forward.~~

The equal and opposite force isn't applied to the same object as the initial action force, so it doesn't prevent motion. The reaction force acts back on the gardener, not on the wheelbarrow.

Q: Explain why it's difficult to walk on slippery surfaces e.g., wet bathroom floors.

The water lowers the frictional force between the floor and your feet so the chance of sliding or not stopping is increased.

Q: Explain why the rear drive wheels of an accelerating rally car throw up clumps of dirt.

The clumps of dirt experience the equal but opposite reaction force to that of the rear drive wheels spinning quickly.

Q: Explain why joggers who run on grass tend to suffer fewer injuries than joggers who run on concrete/bitumen.

Running on grass provides a slightly more elastic surface than concrete or bitumen so the time it takes your feet to stop moving after every stride is slightly increased. This in turn will reduce the force acting on your feet ($F \propto \frac{1}{t}$) and hence the force experienced by your joints and muscles is reduced.

Q: Explain why you're more likely to have an accident on your bicycle if you're riding it on a gravel or wet pathway.

The gravel or water lowers the frictional forces between the tyres and the ground so the chances of sliding, not stopping or failing to turn is increased.

Q: Explain why it's dangerous to allow people to travel in the back of utility trucks.

A moving body will keep moving unless an unbalanced external force restrains it. A person in the back of a utility has no such restraining force, so if the vehicle suddenly stops, the person will continue moving at the same initial velocity of the truck.

Q: Why does moving quickly and coming to a sudden stop relate to knee injuries?

F = $\frac{m(v-u)}{t}$. So, if the time taken to stop is short, the force is larger, hence a greater impact on joints and muscles.

Q: Why do athletes use more energy during a one-hour training session on the beach than during a similar session on a grass field?

On contact with the soft sand the athlete's feet take longer to come to rest and they move further into the surface, so they have to work harder to raise them and get them moving again. So, they use more of the chemical energy they have acquired from their food and their muscles have to expend more of their stored elastic potential energy. In one hour, their body would generate more energy.

Q: Explain why it's an advantage to keep the centre of gravity at a constant height when an athlete leaps over hurdles.

Raising your centre of gravity means hurdlers have to use some of their chemical and elastic potential energy to overcome the gravitational force, meaning they have less energy to transfer into kinetic energy and therefore will not run as quickly.

Q: Why does it require less energy to roller skate than to walk the same distance?

Roller skates effectively contact the ground at a point rather than over a larger surface area which is the situation with the soles of your feet, therefore they work against a much smaller frictional force. This means that your legs can apply a much smaller push force to move, using less energy.

Q: Why does a sprinter start in a crouched position?

Crouching offers a much smaller surface area therefore a reduced drag or air resistance force at the start of the sprint. This means that more of the sprinter's chemical and elastic potential energy can be used to generate a greater initial acceleration burst, producing an increase in speed more quickly.

Q: Why does walking up a hill involve more work than walking the same distance along the flat?

When walking up a hill, you have to overcome an additional gravitational force, meaning you have less energy to transfer into kinetic energy and therefore you will have to work harder to cover the same distance.

Q: Why are the best long jumpers also very fast sprinters?

The more kinetic energy a long jumper has on take-off the more gravitational potential energy they will acquire while in the air. This means they should be able to gain additional height and stay in the air longer, thereby producing a longer jump. This means they can acquire a lot of kinetic energy to sprint quickly.

Q: Why do high jumpers throw their arms into the air just before they leave the ground to clear the bar?

When high jumpers push their arms forward, they are using Newton's third law (equal and opposite reaction) to gain an additional push from the ground in order that they jump with a greater force.

Q: Why does a feather flutter to the ground while a stone plummets while a piece of limestone and a similar sized but heavier granite stone both appear to hit the ground at the same time?

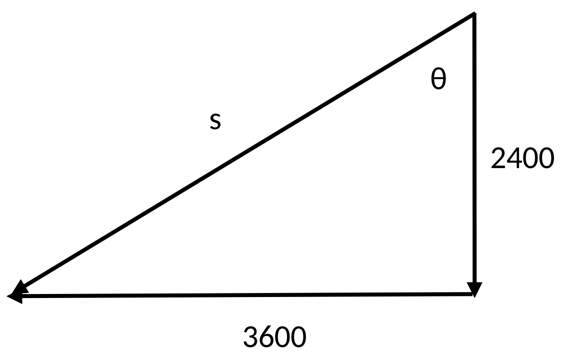
Since the limestone and granite stone are compact masses then air resistance would be negligible, so in the absence of any forces other than gravity, both stones would fall at the same rate ($9.8ms^{-2}$) and hit the ground at the same time. The feather is not a compact mass and air resistance will have a significant impact as it falls, greatly reducing the resultant force acting upon it. Hence it falls much slower.

A car travels 2.40km south in 10.0 minutes and then 3.60km west in 25.0 minutes.

[a] What's the average speed of the car?

Speed = $\frac{2400+3600}{10 x\, 60+25 x\, 60}$ = 2.86 ms^{-1}

[b] What's the car's displacement from its starting point at the end of the journey?



s = $\sqrt{2400^2+3600^2}$ = 4330

θ = $\tan^{-1}(\frac{3600}{2400})$ = 56.3°

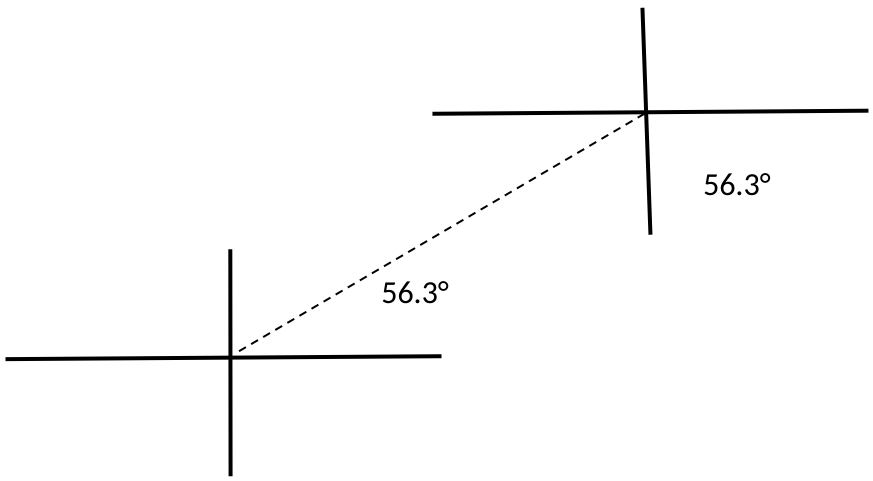
TB = 180 + 56.3 = 236°

s = 4330m 236°

[c] What's the car's average velocity?

v = $\frac{4330}{10 x\, 60+25 x\, 60}$ = 2.06 ms^{-1} 236°

[d] If the car had to head straight back to its starting point in which direction must it go?



TB = 056°

Determine the stopping distance of a car travelling at 60.0km h^{-1} when a truck pulls across the road in front of them. Assume the reaction time (time to react to stimulus and apply brake) is 0.500s and the braking deceleration of the car is at an average of 6.00ms^{-2}. The stopping distance is the sum of the reaction distance and the braking distance.

Reaction distance = $\frac{60}{3.6}$ x 0.5 = 8.33m

$v^2 = u^2 + 2as \rightarrow 0^2 = 8.33^2 + 2 \times -6 \times s$

Braking distance = 11.6m

Stopping distance = 8.33 + 11.6 = 19.9m

Jake is working on the top of a building which is 21.5m above the ground. He drops a bolt which has a mass of 5.55×10^{-2} kg. Assuming the bolt flies straight to the ground and there's no air resistance, calculate:

[a] The time it takes for the bolt to reach the ground.

$-21.5 = \frac{1}{2} \times -9.8 \times t^2$

$t = 2.09s$

[b] The final velocity of the bolt as it hits the ground.

$v = u + at = 0 - 9.8 \times 2.09 = -20.5ms^{-1}$

[c] The ground consists of soft soil and the bolt enters the soil and stops 2.25cm below the surface calculate the magnitude of the deceleration of the bolt.

$0 = (-20.5)^2 + 2 \times a \times (2.25 \times 10^{-2})$

$a = -9360ms^{-2} \rightarrow$ magnitude $= 9360ms^{-2}$

Q: What forces act on a hammer and a nail when a heavy hammer hits a small nail?

The force on the nail by the hammer and the force on the hammer by the nail.

Q: A swimmer completes a training drill in which he doesn't use his legs to kick, but only uses his stroke to move down the pool. What force causes a swimmer to move forwards down the pool?

The force on the hand by the water.

Q: When an inflated balloon is released, it will fly around the room. What's the force that causes the balloon to move?

The force on the balloon by the escaping air.

In summary, to explain why an object is moving, it's always **something else's force acting on the moving object** that **causes it to move**.

Q: An empty truck of mass 2000kg has a top acceleration of 2ms^{-2}. The mass of one box is 300kg. How many boxes would be loaded if the truck's top acceleration decreased to 1.25ms^{-2}?

F_{truck} = 2000 x 2 = 4000N

$m_{truck} = \frac{4000}{1.25} = 3200$

m_{boxes} = 3200 – 2000 = 1200

Number of boxes = $\frac{1200}{300}$ = 4

Q: The thrust force of a rocket with a mass of 50 000kg is 1 000 000N. Neglecting air resistance, calculate its acceleration.

$a_{up} = \frac{1\,000\,000}{50\,000} = 20ms^{-2}$

$a_{down} = 9.8ms^{-2}$

a = 20 – 9.8 = 10.2ms^{-2}

When we walk, our feet push backwards on the ground so the ground pushes forwards on us with the same size force.

F_1 = Us pushing on the ground.

F_2 = Ground pushing on us.

TICKER TIMERS

- Frequency(f) is 50 Hz : 50 ticks in 1 second.
- Period (T) = time for 1 oscillation ie time for 1 tick to next.
- T = 1/f   T = 1/50 = 0.02s
- f=1/T
- Distance can be measured off the tape.
- Time interval can be calculated.
- $\text{SPEED} = \dfrac{\text{DISTANCE(TAPE)}}{\text{TIME INTERVAL}}$

A 0.10 kg hockey puck is at rest. A force of 20.0 N acts on it for 0.20 s, which sets it in motion. Over the next 2.00 s it encounters an average of 0.40 N frictional force. Lastly, a force of 24.0 N acts for 0.05 s in the direction of motion. Calculate the puck's final speed.

$a_1 = \dfrac{20}{0.1} = 200ms^{-2}$

$v - u = 200 \times 0.2 = 40ms^{-1} \rightarrow v = 40ms^{-1}$

$a_2 = \dfrac{-0.4}{0.1} = -4ms^{-2}$

$v - u = -4 \times 2 = -8$

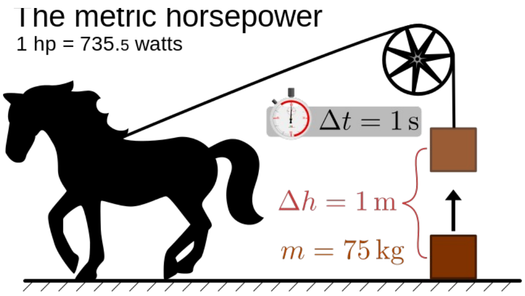
$u = 40 \rightarrow v = 40 - 8 = 32ms^{-1}$

$a_3 = \dfrac{24}{0.1} = 240ms^{-2}$

$v - u = 240 \times 0.05 = 12ms^{-1}$

$u = 32 \rightarrow v = 32 + 12 = 44ms^{-1}$

Horsepower (hp) is an old unit to measure Power, the rate at which work is done. The diagram below shows that 1.00 hp is needed to lift a 75.0 kg mass by 1.00 m in 1.00 s.



[a] Show by calculation that 1.00 hp = 735 W.

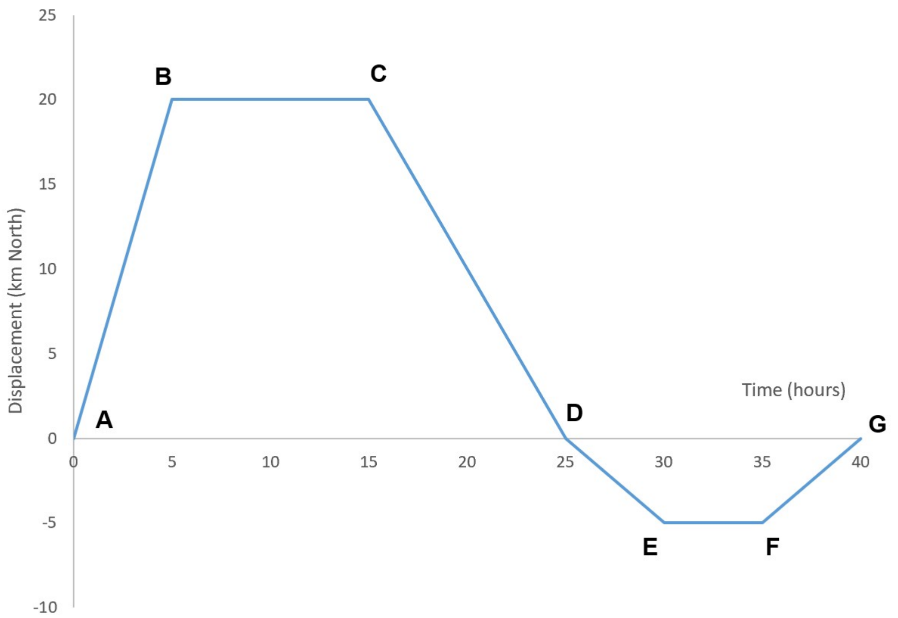
W = mgh = 75 x 9.8 x 1 = 735J

P = $\frac{W}{t}$ = $\frac{735}{1}$ = 735W

[b] If a 12.5 hp air conditioner is working for 2 minutes 15 seconds, calculate how much work has been done.

W = Pt = (735 x 12.5) x 135 = 1.24MJ

A keen bushwalker went for an extended hike as shown by the following graph.



Use the graph to determine the following information:

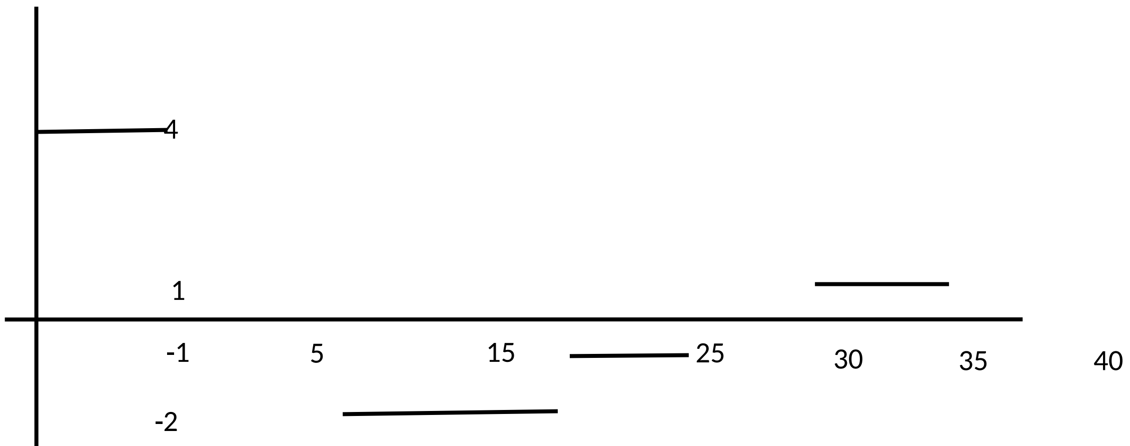
[a] How far did the hiker walk?

20 + 20 + 5 + 5 = 50km

[b] Calculate the velocity (km h^{-1}) in the segment CD

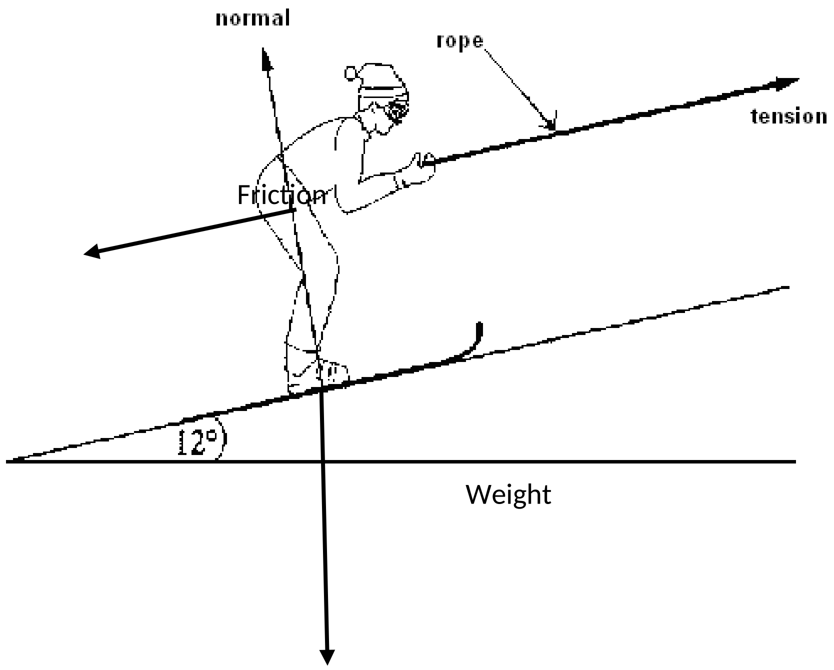
v = $\frac{-20}{10}$ = –2.00ms^{-1} = 2.00ms^{-1} south

[c] Sketch a graph of velocity versus time for the bushwalker's hike.



The figure below shows a skier being pulled by rope up a hill of incline 12.0° at a

constant speed. The total mass of the skier is 85.0 kg. Two of the forces acting on the skier are already shown.



Mark with **arrows** and **label** on the diagram above a further **two (2)** forces that are acting on the skier.

[b] Calculate the minimum tension in the rope pulling on the skier.

$W_{parallel}$ = 85 x 9.8 x sin12 = 173N

On the way to school, a student decides not to use the pedestrian bridge to cross a busy road, and decides instead to run across the road. He sees a car 100 m away travelling towards him, and is confident that he can cross in time.

[a] The car is travelling at 105 km h^{-1} and the student can run at 10.0 km h^{-1}, calculate their respective speeds in m s^{-1}.

Car's speed = 29.2ms^{-1}

Student's speed = 2.78ms^{-1}

[b] If the road has 3 lanes, and each lane is 3 m wide, how long will it take for the student to cross all three lanes, from kerb to kerb?

t = $\frac{s}{v}$ = $\frac{9}{2.78}$ = 3.24s

[c] If the car is travelling in the furthermost lane from the student, will he be able to cross all three (3) lanes of the road safely? Justify your answer with a calculation.

t = $\frac{s}{v}$ = $\frac{100}{29.2}$ = 3.43s

The time it takes for the car to reach where the student was is longer than the time it takes for the student to cross the road and so the student will cross safely.

In a game of 10-pin bowling, a person bowls a 10.5 kg bowling ball so that it hits the last remaining 1.0 kg bowling pin at 2.4 m s^{-1} and continues after the collision at 1.94 m s^{-1}. Calculate the speed of the pin immediately after the collision.

10.5 x 2.4 = 10.5 x 1.94 + v → v = 4.83ms^{-1}

The La Quebrada Cliff Divers® are a group of professional high divers based in Acapulco, Mexico. They regularly dive headfirst from a height of 36.0 m into a narrow inlet of ocean water. The water depth varies from 1.80 m to 4.90 m as the ocean waves surge in and out of the inlet. The average depth is 3.60 m.

[a] A diver jumped verically upwards from the cliff with an initial vertical velocity of 3.5 m s^{-1}. Calculate the kinetic energy of a 60.0 kg diver at the instant he reached the water.

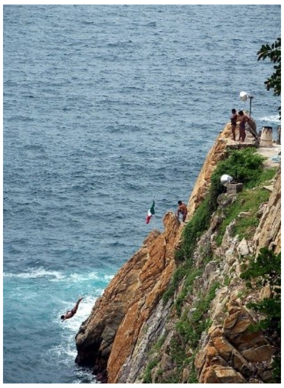
$$v^2 = u^2 + 2as = 0 = 3.5^2 + 2(-9.8)s$$
$$s = 0.625\ m \quad (1)$$
$$PE = mgh = 60 \times 9.8 \times (36 + 0.625) \quad (1)$$
$$PE = 21535.5\ J \quad (1)$$
$$KE = PE = 21500\ J \quad (1)$$

[b] If he came to stop at a depth of 3.00 m, what average vertical force must the water exert on him?

s = 3m

F = $\frac{W}{s}$ = $\frac{21500}{3}$ = 7180N upwards

[c] The divers time their dive by observing the waves at the entrance of the inlet, to their right. The aim is to land as the wave passes under them, hence the water is at a maximum depth. Calculate how far away from the landing zone a wave peak travelling at 12 m s^{-1} would need to be for the diver in part a) to hit the water when at its maximum depth.



$$s = ut + \frac{1}{2}at^2 = 36.625 = 0 + \frac{1}{2}9.8t^2 \quad (1)$$
$$t = 2.73395\,s \quad (1)$$
$$s = vt = 12 \times 2.73395 \quad (1)$$
$$s = 32.8\,m \quad (1)$$

[d] The rocks at the base of the cliff protrude horizontally 4m into the water from where the divers jump. Explain, in terms of forces, why a diver would be killed if they hit these rocks.

Hitting a rock the diver will experience a much larger force than hitting the water (1). When hitting the rock the diver will come to a near-instant stop, when hitting the water the the diver takes a longer time to stop. Since the momentum of the diver is the same in both scenarios, the impulse will be the same. $\Delta p = Ft$ so with Δp being constant, the much smaller time coming to a stop against the rock results in a much larger force. (1)

A young boy is using a horizontal rope to push his cart at a constant velocity. A frictional force of 25N also acts on the cart.

[a] What force must the boy apply to the rope?

25N

[b] The boy's father then attaches a longer rope to the cart because the short rope is uncomfortable to use. The rope now makes an angle of 30° to the horizontal. What's the horizontal component of the force that the boy needs to apply in order to move the cart with constant velocity?

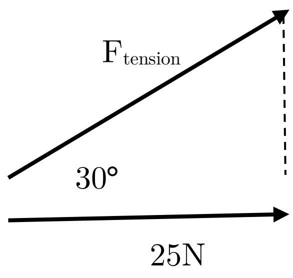
25N

[c] What's the tension force acting along the rope that the boy must apply?

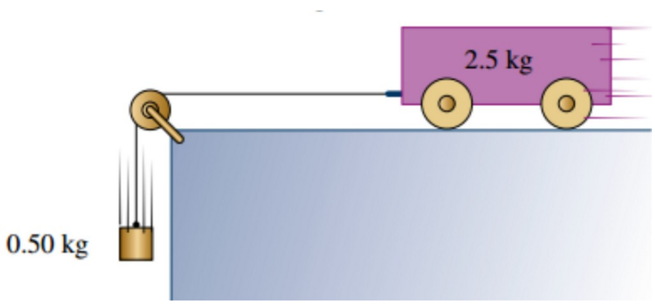
$\cos 30 = \frac{25}{F_{tension}}$

$F_{tension} = \frac{25}{\cos 30} = 28.9N$

at an angle of 30° to the horizontal.



A 0.50kg metal block is attached by a piece of string to a dynamics cart, as shown below. The block is allowed to fall from rest, dragging the cart along. The mass of the cart is 2.5kg.



[a] If the friction is ignored, what's the acceleration of the block as it falls?

F = ma = 0.5 x 9.8 = 4.9N

$a = \frac{F}{m} = \frac{4.9}{2.5+0.5} = 1.63ms^{-2}$

[b] How fast will the block be travelling after 0.50s?

v = u + at = 0 + 1.63 x 0.5 = $0.817ms^{-1}$

[c] If a frictional force of 4.3N acts on the cart, what's its acceleration?

F = 4.9 – 4.3 = 0.6N

$$a = \frac{F}{m} = \frac{0.6}{2.5+0.5} = 0.200\text{ms}^{-2}$$

A 70kg fisherman is fishing in a 40kg dinghy at rest on a still lake when, suddenly, he's attacked by a swarm of wasps. To escape, he leaps into the water and exerts a horizontal force of 140N north on the boat.

[a] What force does the boat exert on the fisherman?

140N in the opposite direction to the leaping fisherman (south).

[b] If the force on the fisherman lasted for 0.50s, determine the initial speed attained by both the man and the boat.

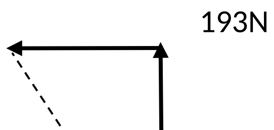
$$a_{\text{fisherman}} = \frac{F}{m} = \frac{140}{70} = 2\text{ms}^{-2}$$

$$v_{\text{fisherman}} = u + at = 0 + 2 \times 0.5 = 1.00\text{ms}^{-1}$$

$$a_{\text{boat}} = \frac{F}{m} = \frac{140}{40} = 3.5\text{ms}^{-2}$$

$$v_{\text{boat}} = u + at = 0 + 3.5 \times 0.5 = 1.75\text{ms}^{-1}$$

Ike and Mike each hit a 96g ball with sticks at the same time. Ike strikes with a force of 217N North, while Mike strikes with a force of 193N West. Determine the acceleration of the ball.



$R = \sqrt{193^2 + 217^2} = 290N$

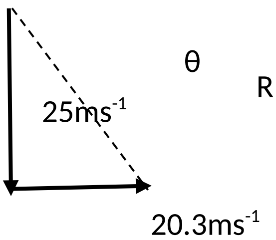
$\theta = \tan^{-1}(\frac{193}{217}) = 41.6°$

R 217N

θ TB = 360 – 41.6 = 318°

$a = \frac{F}{m} = \frac{290}{0.096} = 3030ms^{-2}$ 318°

A 3520kg vehicle hits a wall at 90km h^{-1} N and bounces off at 73 km h^{-1} E. What was the acceleration of the car if the collision took 0.84s.



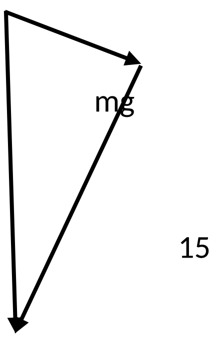
$R = \sqrt{20.3^2 + 25^2} = 32.2ms^{-1}$

$\theta = \tan^{-1}(\frac{20.3}{25}) = 39.0°$

TB = 180 – 39.0 = 141°

$a = \frac{32.2}{0.84} = 38.3ms^{-2}$ 141°

A 1.42 tonne truck accelerates at 0.1ms^{-2} up a 15° incline. If the friction is 240N, what's the truck's driving force?



$\sum F = ma = 1420 \times 0.1 = 142N$

$F = ma = F_{driving} – 240 – (1420)(9.8)\sin 15$

= 3980N upslope

A frog jumps off a 30cm bucket at 6ms^{-1} up. How long does it take to land on the ground below? How fast is it travelling when it hits ground?

$0^2 = 6^2 + 2(-9.8)s$

$s = 1.84m$

$v^2 = 0^2 + 2(-9.8)(1.84+0.3)$

$v^2 = u^2 + 2as$

12.5ms^{-1} down.

John is going for his favourite bike ride at a steady 18.0kmh^{-1} when he passes his stationary friend Jason. Jason immediately sets off after John and accelerates at 2.40ms^{-2} until he reaches his top speed 3.00s later. He then continues at this top speed as he cycles towards John.

[a] Does Jason catch John? Clearly show all calculations.

Top speed (Jason) = 2.4 x 3 = 7.20ms^{-1}

Top speed (John) = 5.00ms^{-1}

Jason reaches a higher velocity than John.

He will catch John.

[b] If so, how far did he travel before he reached John?

$s_{John} = vt = 5t$

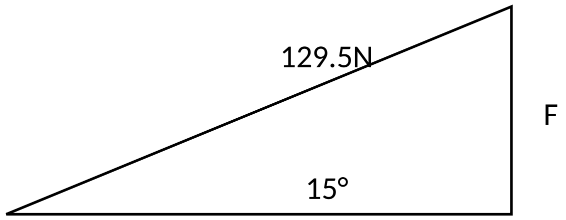
$s_{Jason} = \frac{1}{2} \times 3 \times 7.2 + 7.2(t - 3)$

$5t = 10.8 + 7.2t - 21.6$

t = 4.91s (to catch John)

$s = vt = 5 \times 4.91 = 24.6m$

A cable car accelerates up a 15° incline at 0.15ms^{-2}. Determine the vertical component of tension in the 2 vertical cables. Mass is 864kg.



F = 129.6sin15 = 33.5N

$\sum F = W + F_T$

$F_T = \frac{33.5 - (864)(-9.8)}{2}$ = 4220N up

(in one cable)

A 6g bullet travelling at 1025ms^{-1} passes through a 7g coke can. If the bullet comes out at 1015ms^{-1} how fast is the can moving?

(0.006)(1025) = (0.006)(1015) + (0.007)v

v = 8.57ms^{-1} in the same direction of the bullet.

Q: With reference to physics concepts, explain the purpose of airbags, seatbelts and headrests in a car.

~~Airbags and headrests: Increasing the time it takes for the driver/passenger to come to a stop will decrease the resultant force acting on the person since F =~~ $\cancel{\frac{\Delta p}{t}}$~~, therefore decreasing the likelihood of injury.~~

~~Seatbelts: An object in motion will continue in its state of motion unless acted upon by an unbalanced external force. If a vehicle suddenly stops, the driver and passengers will continue moving at the same velocity unless acted upon by a restraining external force. The seatbelt acts as this restraining force to prevent the people from flying forwards.~~

Airbag: Provides safe object for body to hit, increasing time taken for body to stop, since impulse will be constant the force applied to the body is reduced (Δp = Ft).

Seatbelt: In a sudden stop, your body will attempt to keep moving due to inertia. The seatbelt provides an opposing force to keep you in the seat.

Headrest: In rear-end collision, chest would be pushed forwards while head remains where it is due to inertia, causing a neck injury. A headrest prevents this.

The La Quebrada Cliff Divers® are a group of professional high divers based in Acapulco, Mexico. They regularly dive headfirst from a height of 36.0 m into a narrow inlet of ocean water. The water depth varies from 1.80 m – 4.90 m as the ocean waves surge in and out of the inlet. The average depth is 3.60 m.

[a] A diver jumped verically upwards from the cliff with an initial vertical velocity of 3.5 ms^{-1}. Calculate the kinetic energy of a 60.0 kg diver at the instant he reached the water.

[b] If he came to stop at a depth of 3.00 m, what average vertical force must the water exert on him?

[c] The divers time their dive by observing the waves at the entrance of the inlet, to their right. The aim is to land as the wave passes under them, hence the water is at a maximum depth. Calculate how far away from the landing zone a wave peak travelling at 12 ms^{-1} would need to be for the diver in part a) to hit the water when at its maximum depth.