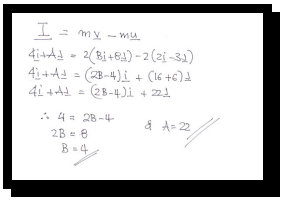
IMPULSE

Question 1 (**)

A particle of mass 2 kg is travelling with velocity $(2\mathbf{i}-3\mathbf{j})$ ms^{-1} when it receives an impulse of $(4\mathbf{i}+A\mathbf{j})$ Ns, where A is a constant. The velocity of the particle after it receives the impulse, is $(B\mathbf{i}+8\mathbf{j})$ ms^{-1}.

Find the value of A and the value of B.

$\boxed{A=22}$, $\boxed{B=4}$



Question 2 (**)

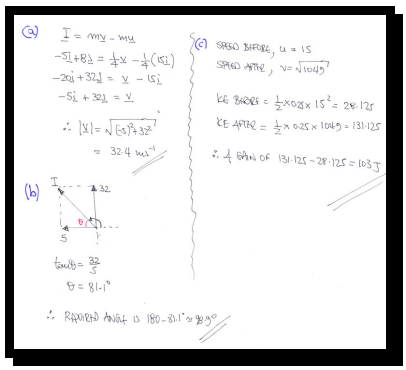
A cricket ball of mass 0.25 kg is travelling with velocity $15\mathbf{i}$ ms^{-1} when it is struck by a bat. The ball receives an impulse of $(-5\mathbf{i}+8\mathbf{j})$ Ns. The cricket ball is modelled as a particle and air resistance is ignored.

a) Determine the speed of the cricket ball after the impact.

b) Calculate the angle that the velocity of the cricket ball after impact makes with the vector $\mathbf{i}$.

c) Find the kinetic energy gain of the cricket ball, as a result of the impact.

$\boxed{v\approx 32.4 \text{ ms}^{-1}}$, $\boxed{98.9°}$, $\boxed{103 \text{ J}}$



Question 3 (**)

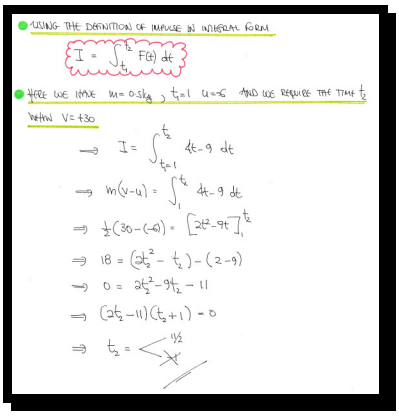
A particle of mass 0.5 kg is moving in a straight line on a smooth horizontal surface.

The particle is acted on by a horizontal force of magnitude $(4t-9)$ N, where t represents the time, in seconds, measured from a certain instant.

At time $t=1$, the particle has speed 6 ms^{-1}.

Find the value of t when the particle has a speed of 18 ms^{-1}.

$\square$, $\boxed{t=\frac{11}{2}=5.5}$

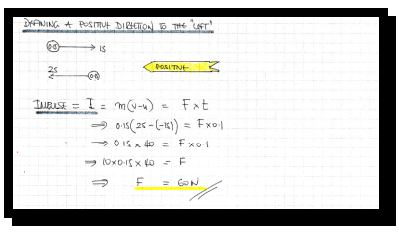


Question 4 (**)

A cricket ball, of mass 0.15 kg reaches a batsman with horizontal velocity of 15 ms^{-1}. It is struck in such a way so that it leaves the bat with a horizontal velocity of 25 ms^{-1}.

If the bat and the ball are in contact for 0.1 s, determine the average force exerted by the bat on the ball.

$\square$, $\boxed{60 \text{ N}}$



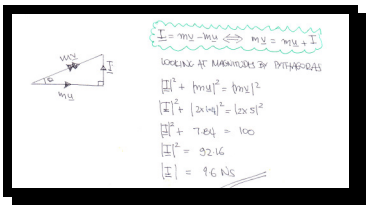
Question 5 (+)**

A particle of mass $2\,\text{kg}$ is moving on a smooth horizontal plane with speed $1.4\ \text{ms}^{-1}$ when it receives an impulse of magnitude I Ns, in a direction perpendicular to its direction of motion.

The speed of the particle after it receives I changes to $5\ \text{ms}^{-1}$.

Determine the value of I.

$$\boxed{I=9.6}$$



Question 6 (+)**

An ice hockey player of mass $75\,\text{kg}$ after being tackled by another hockey player is heading with constant speed of $6\ \text{ms}^{-1}$ towards the vertical cushioned wall, in the perimeter of the ice rink.

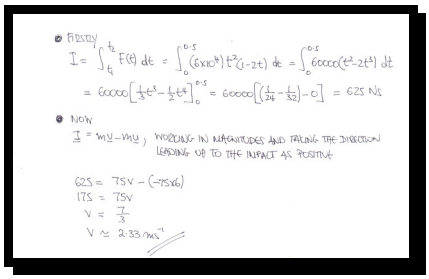
The cushioning exerts a force F N, acting in a direction perpendicular to wall and its magnitude is given by

$$F=6\times10^4t^2\left(1-2t\right),\ 0\le t\le 0.5\,.$$

The player remains in contact with the cushioning for 0.5 s

Determine the speed of the hockey player after he rebounds off the cushioned wall.

$$\boxed{v=\frac{7}{3}\approx 2.33\ \text{ms}^{-1}}$$



Question 7 (+)**

A particle of mass 5 kg is moving in a straight line on a smooth horizontal surface under the action of a single force F which varies with time t as

$$F(t)=(12-2t)\,\text{N},$$

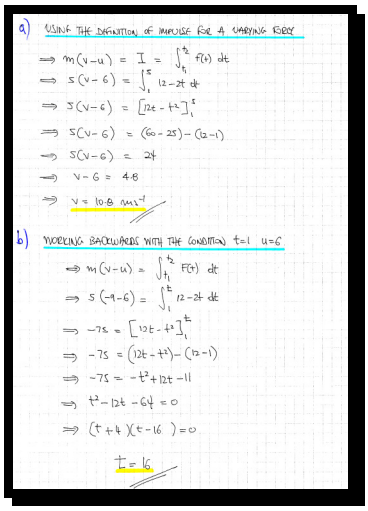
where t is measured in seconds since an arbitrary instant.

When $t=1$ the particle has velocity 6 ms^{-1}.

a) Determine the velocity of the particle when $t=5$.

b) Find the value of t when the velocity of the particle is -9 ms^{-1}.

$\boxed{}$, $\boxed{v=10.8\text{ ms}^{-1}}$, $\boxed{t=16}$



Question 8 (+)**

A particle of mass m kg is moving in a straight line on a smooth horizontal surface under the action of a single force F which varies with time t as

$$F(t)=\left(5t^{\frac{3}{2}}-2t\right)\text{N},$$

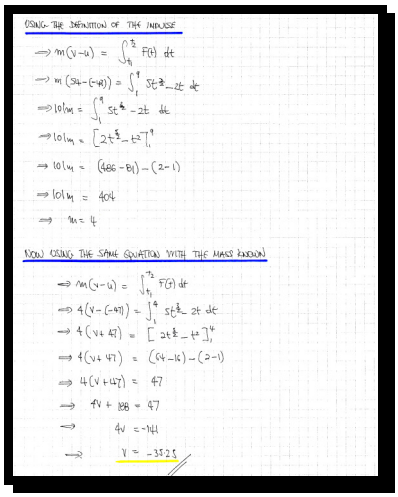
where t is measured in seconds since an arbitrary instant.

When $t=1$ the particle has velocity -47 ms^{-1}.

When $t=9$ the particle has velocity 54 ms^{-1}.

Determine the velocity of the particle when $t=4$.

$\boxed{}$, $\boxed{v=-35.25 \text{ ms}^{-1}}$



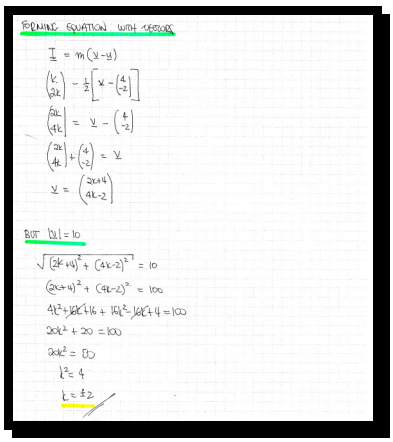
Question 9 (***)

A particle, of mass 0.5 kg moving with velocity of $(4\mathbf{i}-2\mathbf{j})$ ms^{-1} receives an impulse $(k\,\mathbf{i}+2k\,\mathbf{j})$ Ns , where k is a constant.

After receiving the impulse the particle is moving with speed 10 ms^{-1}.

Determine the possible values of k .

$\boxed{}$, $\boxed{k=\pm 2}$



Question 10 (***)

In this question $\mathbf{i}$ *and* $\mathbf{j}$ *are mutually perpendicular unit vectors.*

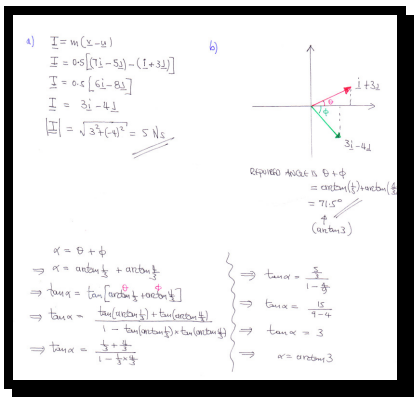
A particle P of mass $0.5\,\text{kg}$ is moving with velocity $(\mathbf{i}+3\mathbf{j})\ \text{ms}^{-1}$ when it receives an impulse $\mathbf{I}$ Ns.

Immediately after $\mathbf{I}$ is applied, P has velocity $(7\mathbf{i}-5\mathbf{j})\ \text{ms}^{-1}$.

a) Find the magnitude of the impulse.

b) Calculate the angle between the direction of $\mathbf{I}$ and the direction of motion of P immediately is $\mathbf{I}$ applied.

$$\boxed{|\mathbf{I}|=5}\,,\qquad \boxed{\arctan 3\approx 71.5^\circ}$$



Question 11 (***)

In this question $\mathbf{i}$ *and* $\mathbf{j}$ *are mutually perpendicular unit vectors.*

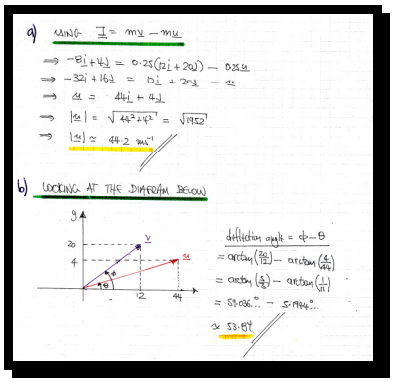
A small ball of mass 0.25 kg is moving on a smooth horizontal surface when it is struck by a bat. The bat exerts an impulse $(-8\mathbf{i}+4\mathbf{j})$ Ns on the ball.

Immediately after receiving the impulse the ball has velocity $(12\mathbf{i}+20\mathbf{j})$ ms^{-1}.

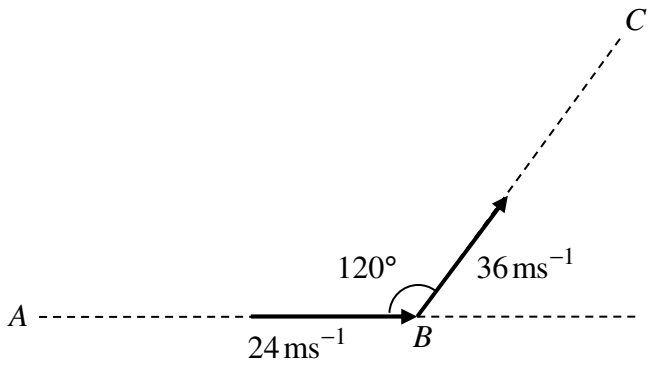
a) Find the speed of the ball immediately before the impact.

b) Calculate the size of the angle through which the direction of motion of the ball is deflected by the impact.

$\boxed{}$, $\boxed{\text{speed} = \sqrt{1952} = 4\sqrt{122} \approx 44.2 \text{ ms}^{-1}}$, $\boxed{\approx 53.8^\circ}$



Question 12 (***)



The figure above shows the plan of the path of a cricket ball of mass 0.25 kg, passing through the points A, B and C, which lie on the same horizontal plane.

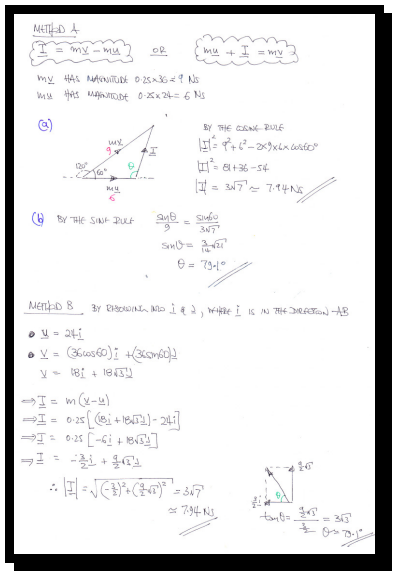
The cricket ball is moving along AB with speed 24 ms^{-1}. The cricket ball is being struck by a bat at B and immediately after the strike, the cricket ball is moving along BC with speed 36 ms^{-1}. The angle ABC is $120°$, as shown in the figure.

The cricket ball is modelled as a particle moving without any resistance, on the same horizontal level.

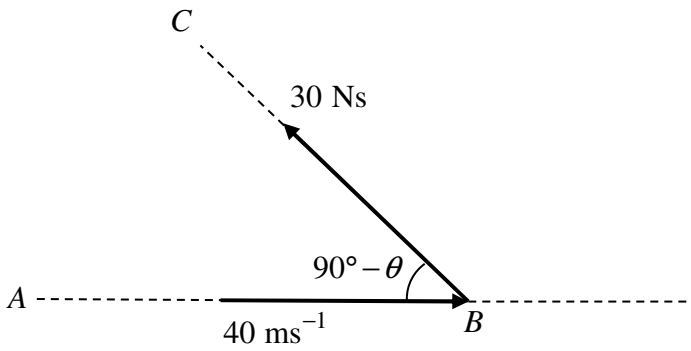
a) Find the magnitude of the impulse exerted by the bat onto the cricket ball.

b) Determine the acute angle the impulse makes with the line AB.

$$\boxed{|\mathbf{I}| = 3\sqrt{7} \approx 7.94 \text{ Ns}}, \quad \boxed{\approx 79.1°}$$



Question 13 (***)



The points A, B and C, which lie on the same horizontal plane. A ball of mass 0.5 kg is travelling along AB with speed 40 ms^{-1} when it receives an impulse I of magnitude 30 Ns, in the direction BC.

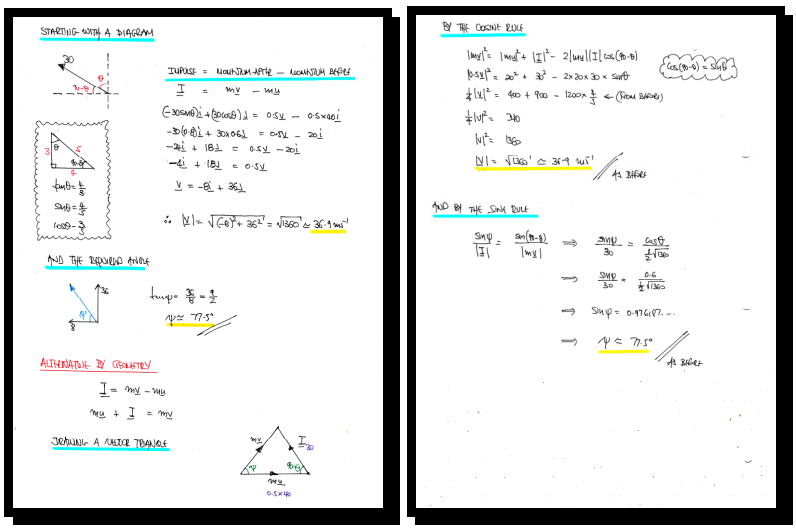
The angle ABC is $90° - \theta$, as shown in the figure, where $\tan\theta = \frac{4}{3}$.

The ball is modelled as a particle moving without any resistance.

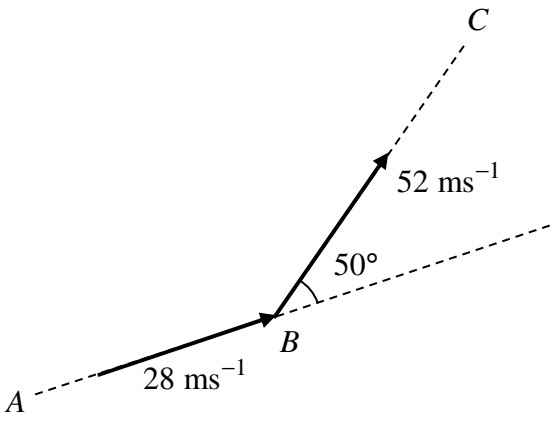
a) Find the magnitude of the velocity of the ball, immediately after it receives I.

b) Determine the acute angle the velocity of the ball makes with the direction AB, immediately after it receives I.

$\boxed{}$, $\boxed{|\mathbf{v}| = 4\sqrt{85} \approx 36.9 \text{ ms}^{-1}}$, $\boxed{\approx 77.5°}$



Question 14 **(***+)**



The figure above shows the plan of the path of a cricket ball of mass 0.25 kg, passing through the points A, B and C, which lie on the same horizontal plane.

The cricket ball is moving along AB with speed 28 ms^{-1}.

The cricket ball is being struck by a bat at B and immediately after the strike, the cricket ball is moving along BC with speed 52 ms^{-1}.

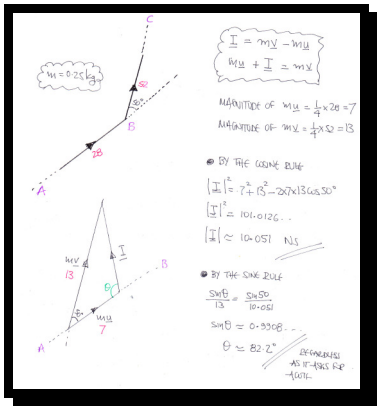
As a result of the impact the path of the cricket ball is deflected by $50°$, as shown in the figure.

The cricket ball is modelled as a particle moving without any resistance, on the same horizontal level.

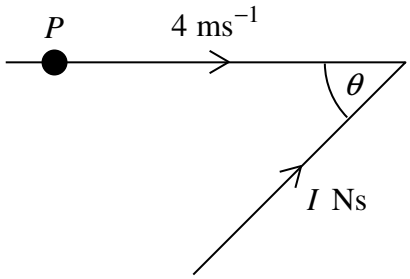
a) Find the magnitude of the impulse exerted by the bat onto the cricket ball.

b) Determine the acute angle the impulse makes with the line AB.

$$\boxed{|\mathbf{I}| \approx 10.051... \text{ Ns}}, \quad \boxed{\approx 82.2°}$$



Question 15 **(***+)**



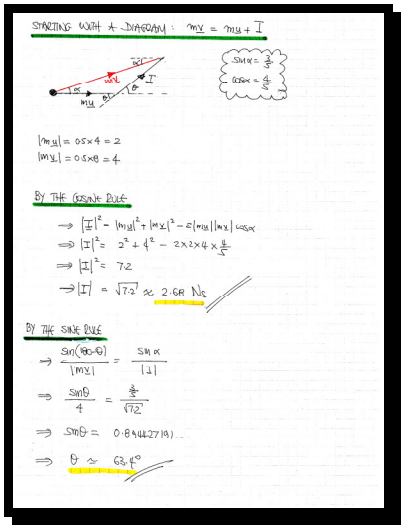
A particle P of mass 0.5 kg is moving in a straight line with speed 4 ms^{-1}.

An impulse of magnitude I Ns is applied to P, acting at an acute angle θ to the direction of motion of P, as shown in the figure above.

After the impulse was applied, P is moving with speed 8 ms^{-1} in a direction which is inclined by an acute angle α to its original direction of motion.

Given that $\sin\alpha = \frac{3}{5}$, determine the value of I and the value of θ.

$\boxed{}$, $\boxed{I = \frac{6}{5}\sqrt{5} \approx 2.68}$, $\boxed{\theta = \arctan 2 \approx 63.4^\circ}$



Question 16 (*+)**

In this question **i** *and* **j** *are mutually perpendicular unit vectors.*

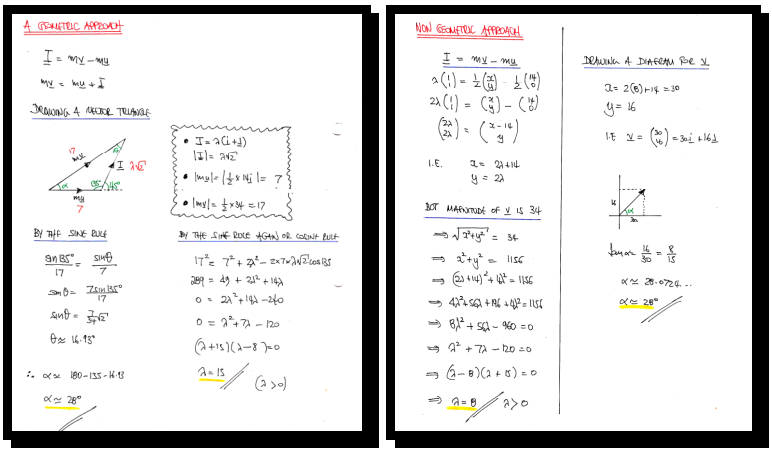
A particle of mass 0.5 kg is moving on a smooth horizontal plane with velocity $14\mathbf{i}$ ms^{-1} when it receives an impulse $\lambda(\mathbf{i}+\mathbf{j})$ Ns , where λ is a positive constant.

Immediately after receiving the impulse the particle is moving with speed 34 ms^{-1}, in a direction which makes an acute angle α with the vector $\mathbf{i}$.

a) Calculate the value of α, correct to the nearest degree.

b) Determine the value of λ.

$\boxed{}$, $\boxed{\alpha \approx 28^\circ}$, $\boxed{\lambda = 8}$



Question 17 (*+)**

A particle P of mass 8 kg is moving on a straight line under the action of a single force F which acts in the direction of motion of P.

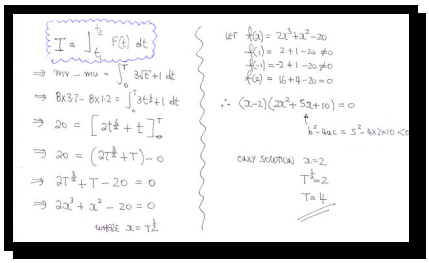
At time t s , $F=\left(3\sqrt{t}+1\right)$ N, $0\le t\le 25$.

When $t=0$, the velocity of P is 1.2 ms^{-1}.

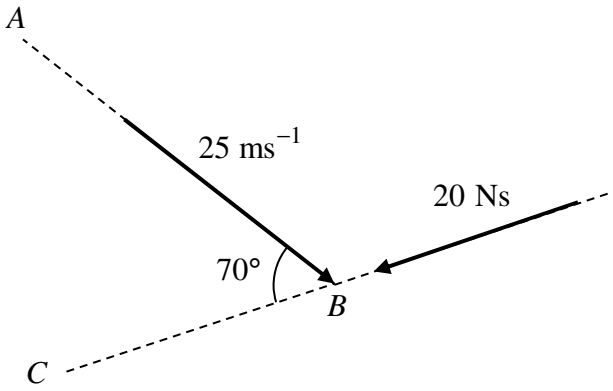
When $t=T$, the velocity of P is 3.7 ms^{-1}.

Determine the value of T

$$\boxed{T=4}$$



Question 18 **(****)**



The figure above shows the plan of the path of a ball of mass 0.2 kg, moving along AB with constant speed 25 ms^{-1}.

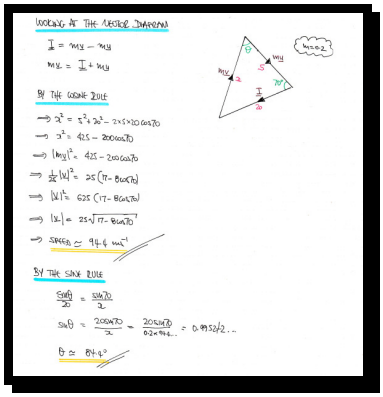
At B the ball receives an impulse of magnitude 20 Ns in the direction BC, where $\measuredangle ABC = 70°$, as shown in the figure.

The points A, B and C, which lie on the same horizontal plane and the ball is modelled as a particle moving without any resistance, on the same horizontal level.

a) Find the speed of the ball after it receives the impulse.

b) Determine the acute angle the speed of the ball makes with the line AB, after it receives the impulse.

$\boxed{}$, $\boxed{\text{speed} \approx 94.4 \text{ ms}^{-1}}$, $\boxed{\approx 84.4°}$



Question 19 (**+)**

Two particles, A and B, of mass 5 kg and 2 kg respectively, are each attached to the ends of a light inextensible string of length $2a$ m. The particles are placed on a smooth horizontal surface so that $|AB| = a$ m.

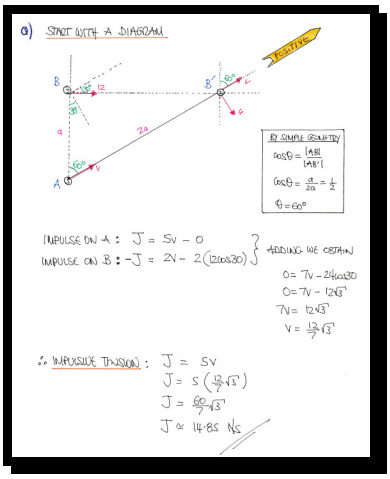
B is projected along the surface with speed 12 ms^{-1} in a direction perpendicular to the straight line joining the initial positions of A and B.

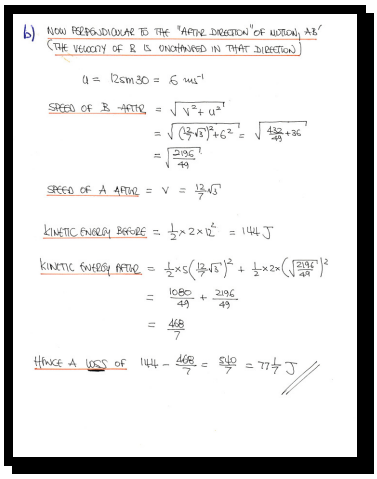
When the string becomes taut, ...

a) ... determine the magnitude of the impulsive tension in the string.

b) ... show that the system experiences a loss of $77\frac{1}{7}$ N, in kinetic energy.

$\boxed{}$, $\boxed{I = \frac{60}{7}\sqrt{3} \approx 14.85 \text{ Ns}}$

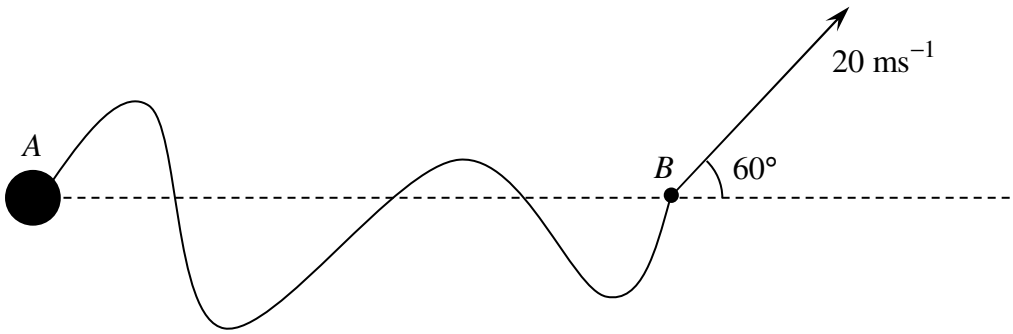




Question 20 (**+)**

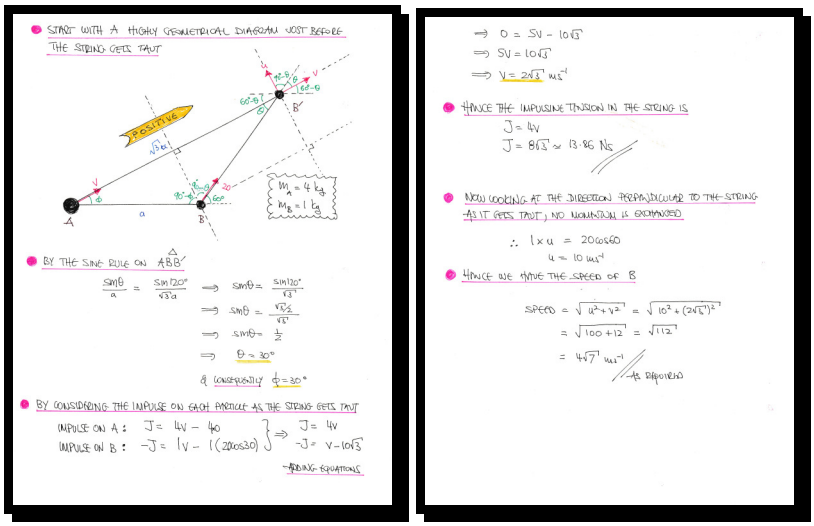
Two particles, A and B, of mass 4 kg and 1 kg respectively, are each attached to the ends of a light inextensible string of length $\sqrt{3}a$ m. The particles are placed on a smooth horizontal surface so that $|AB| = a$ m.

A is projected along the surface with speed 20 ms^{-1} in a direction which makes an angle of $60°$ with the straight line joining the initial positions of A and B, as shown in the figure below.



When the string becomes taut, determine the magnitude of the impulsive tension in the string and show further that the speed of B is $4\sqrt{7}$ ms^{-1}.

$\boxed{}$, $\boxed{I = 8\sqrt{3} \approx 13.86 \text{ Ns}}$



Created by T. Madas