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PHYSICS/FISIKA

STUDY GUIDE

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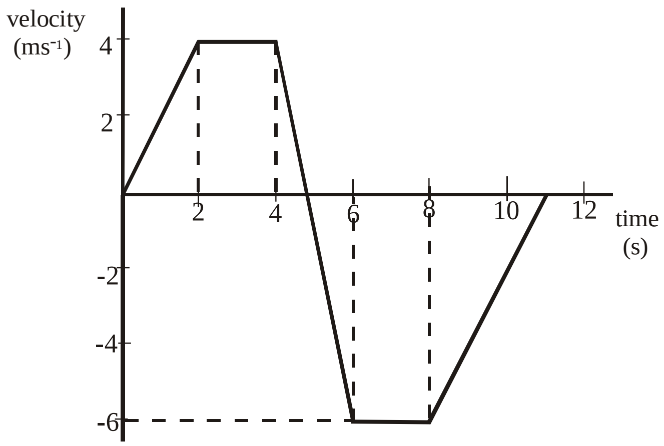
MECHANICS

GENERAL NOTES:

- In this study guide the value for gravitational acceleration will be taken as 9,8 ms^{-2}.
- We use the subscript i for initial values of a certain interval and f for the final values of the interval. For example, v_i will be the initial velocity of a certain interval (instead of u as used in some textbooks) and v_f will be the final velocity of the interval (instead of just v as used in some textbooks.)

PROBLEM 1: GRAPHS OF MOTION

The path of a moving particle is limited to a straight line running north-south. Use a coordinate system where north is positive. The accompanying graph gives the velocity as a function of time. The graph intersects the horizontal axis at 4,8 s and 11 s.



1.1 Complete a table in which you indicate the directions of the velocity in one column and the acceleration in another column for the following instants: 1,0s, 3,0s, 4,2s, 5,0s, 7,0s, 10,0s. In a third column indicate whether the object is moving slower, faster, or maintaining a constant speed.

Time	Velocity	Acceleration	faster/slower
1,0s	North (+)	North (+)	faster
3,0s	North (+)	zero	constant speed
4,2s	North (+)	South (-)	slower
5,0s	South (-)	South (-)	faster
7,0s	South (-)	zero	constant speed
10s	South (-)	North (+)	slower

1.2 What is the total displacement of the object during the journey?

Find the area under the graph. The areas below the x-axis are negative.

Area = $\frac{1}{2}(2)(4) + (2)(4) + \frac{1}{2}(0{,}8)(4) - \frac{1}{2}(1{,}2)(6) - (2)(6) - \frac{1}{2}(3)(6)$

$= -11\,\text{m}$

1.3 What is the average velocity for the entire journey?

Definition of velocity: velocity = displacement ÷ time

$$\vec{v} = \frac{\Delta x}{\Delta t} = \frac{-11\text{m}}{11\text{s}} = -1{,}0\ \text{ms}^{-1}$$

1.4 What is the acceleration

1.4.1. during the first two seconds?

1.4.2 between $t = 4\text{s}$ and $t = 6\text{s}$?

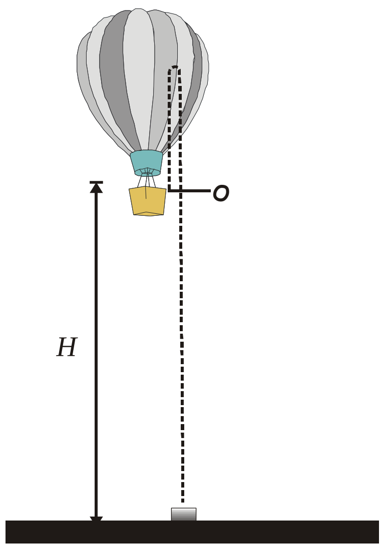
Calculate the gradient of the velocity -time graph.

1.4.1 $a = \frac{\Delta v}{\Delta t} = \frac{4-0}{2-0} = 2\,ms^{-2} \quad \therefore\ 2\,ms^{-2}, \textit{north}$

1.4.2 $a = \frac{\Delta v}{\Delta t} = \frac{-6-4}{6-4} = -5\,ms^{-2} \quad \therefore\ 5\,ms^{-2}, \textit{south}$

PROBLEM 2: FREE FALL MOTION

A Hot air balloon is ascending with a speed of 5,00 ms^{-1}. A person in the basket releases a bag of flour at a height H. The bag strikes the earth with a speed of 18,0 ms^{-1}.



2.1 How long will the bag be in the air?

Choose a coordinate system with the origin (O) at the point where the bag is released and the positive Y-axis pointing upwards. Remember that all the quantities in the equations of motion are vectors (except time). We therefore need to substitute the signs of these quantities together with their magnitudes. There are two ways to solve this problem:

Method 1

Divide the motion in three parts: ① upward to maximum height, ② from the maximum height downward to the origin, and ③ from the origin downward to the ground.

①For the upward motion: $g = -9{,}8\,ms^{-2}$ $\quad v_f = v_i + gt$

$v_i = +5{,}0\,ms^{-1}$ $\quad \therefore 0 = 5 - 9{,}8t$

$v_f = 0$ $\quad \therefore t_1 = 0{,}51\text{s}$

②For downward motion (from maximum height to the origin):

$$v_i = 0$$
$$v_f = -5{,}0\,\text{ms}^{-1}$$
$$\therefore t_2 = 0{,}51\,\text{s} \;\; \text{(same as for 1)}$$

③From the origin to the ground:

$$a = g = -9{,}8\,\text{ms}^{-2} \qquad v_f = v_i + at$$
$$v_i = -5{,}0\,\text{ms}^{-1} \qquad \therefore -18 = -5 - 9{,}8t$$
$$v_f = -18\,\text{ms}^{-1} \qquad \therefore t_3 = 1{,}33\,\text{s}$$

Total time $= t_1 + t_2 + t_3$
$= 0{,}51 + 0{,}51 + 1{,}33$
$= 2{,}35\text{s}$

Method 2

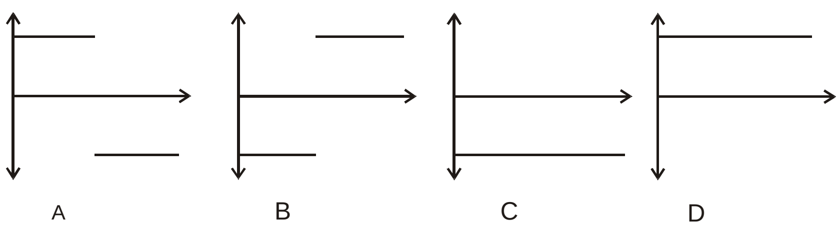
Do not divide the motion into sections, but consider the complete motion at once.

$$a = g = -9{,}8\,\text{ms}^{-2} \qquad v_f = v_i + at$$
$$v_i = 5\text{ms}^{-1} \qquad \therefore -18 = 5 - 9{,}8t$$
$$v_f = -18\,\text{ms}^{-1} \qquad \therefore t = 2{,}35\text{s}$$

2.2 Find H, the height from which the bag was released. Again consider the complete motion.

$$v_i = 5\,\text{ms}^{-1} \qquad s = v_i t + \tfrac{1}{2}at^2$$
$$a = -9{,}8\,\text{ms}^{-2} \qquad = (5)(2{,}35) + \tfrac{1}{2}(-9{,}8)(2{,}35)^2$$
$$t = 2{,}35\text{s} \qquad = -15{,}3\text{m}$$
$$\therefore H = 15{,}3\,\text{m}$$

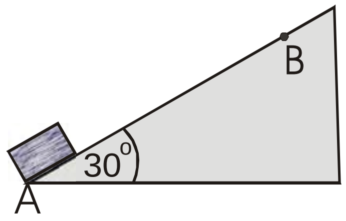
2.3 Which one of the graphs below represents the acceleration-time graph for this motion?



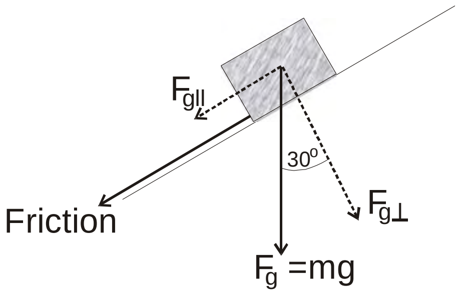
Answer: **C**. A and B are wrong, because they imply that the direction of the acceleration changes after the bag has reached its maximum height, which is of course not true. Gravitational acceleration is always downward. For our choice of coordinate system with the negative y-axis downward, the correct acceleration-time graph is C.

PROBLEM 3: WORK AND ENERGY

A block is kicked at the bottom of an inclined plane (at point A) so that it starts sliding upwards with an initial speed of 2,9 ms^{-1}. The mass of the block is 3,1 kg. A frictional force of 6,5 N is acting on the block. The block comes to rest at point B.



3.1 Draw a force diagram showing the forces acting on the block while it is moving upward.



3.2 Calculate the total work done on the block.

Remember: $W_{tot} = \Delta E_k$ (this is always true)

$$\begin{aligned} W_{tot} &= E_{kf} - E_{ki} \\ &= 0 - \tfrac{1}{2}mv_i^2 \\ &= -\tfrac{1}{2}(3{,}1)(2.9)^2 \\ &= -13\text{ J} \end{aligned}$$

3.3 Calculate the component of the resultant force on the block, parallel to the plane.

$$\begin{aligned} F_{res} &= F_{friction} + F_{gll} \\ &= 6{,}5 + mg\sin 30° \\ &= 21{,}7\text{ N} \end{aligned}$$

3.4 Calculate how far the block will travel up the plane.

Definition of work: $W = F.\Delta x$

Both F and Δx are vectors, therefore we should include signs to indicate their directions. Choose a coordinate system with the x - axis parallel to the inclined plane with positive upwards along the plane.

$\therefore F$ = -21,7 N and Δx is positive

$$\begin{aligned} W &= F.\Delta x \\ -13 &= (-21{,}7)\Delta x \\ \therefore \Delta x &= 0{,}60\text{ m} = \text{the distance AB} \end{aligned}$$

PROBLEM 4: CONSERVATION OF ENERGY

A brick of mass 1,2 kg is thrown off a building, 25 m high, with a speed of 1,1 ms^{-1} directly downwards. As it falls onto the earth, it penetrates 15 cm into the ground. Ignore air friction.

4.1 Calculate the speed with which the brick hits the ground. (Note: This can be solved either by equations of motion or by energy principles. Let's use energy conservation in this case.)

Total mechanical energy at the top = Total mechanical energy at the bottom
(This is true because we ignore air friction)

$$\text{Tot } E_{\underset{\text{at top}}{\text{mech}}} = \text{Tot } E_{\underset{\text{at bottom}}{\text{mech}}}$$

$$\therefore (E_k + E_p)_{top} = (E_k + E_p)_{bottom}$$

$$\therefore \tfrac{1}{2}mv_{top}^2 + mgh = \tfrac{1}{2}mv_{bottom}^2 + 0$$

$$\therefore \tfrac{1}{2}v_{top}^2 + gh = \tfrac{1}{2}v_{bottom}^2$$

$$\tfrac{1}{2}(1{,}1)^2 + (9{,}8)(25) = \tfrac{1}{2}v_{bottom}^2$$

$$\therefore v_{bottom} = 22{,}2 \text{ ms}^{-1}$$

Note that in the fourth step, the mass cancels from the equation. It means that if the brick had a different mass its final speed would still be the same.

4.2 Calculate the total work done on the brick as it enters the ground.

$$W_{tot} = \Delta E_k = E_{kf} - E_{ki}$$

Since it comes to rest in the ground E_{kf} = 0.

$$W_{tot} = -\tfrac{1}{2}mv_i^2 = -(1{,}2)(22{,}2)^2 = -296 \text{J}$$

4.3 Calculate the frictional force exerted by the ground on the brick to bring it to rest. (Let's take downwards as negative.)

$$W_{tot} = F_{res}.\Delta x$$

$$-296 = F_{res}(-0{,}15)$$

$$\therefore F_{res} = 1973 \text{ N}$$

This F_{res} comprises of the contribution by gravity F_g (downward) and friction F_f (upward).

$$-F_g + F_f = F_{res}$$

$$-mg + F_f = 1973$$

$$F_f = 1973 + (1{,}2)(9{,}8) = 1985 \text{ N}$$

4.4 Calculate the change in momentum the brick experiences from the moment it hits the ground until it comes to rest. (Take downwards as negative)

$$\Delta p = mv_f - mv_i$$
$$= 0 - (1,2)(-22,2)$$
$$= 26,6 \text{ kgms}^{-1}$$

4.5 Calculate the time it takes the brick to come to rest from the moment it hits the ground.

$$\text{Impuls} = \text{change in momentum}$$

$$F_{res}.\Delta t = \Delta p$$
$$\therefore (1973)\Delta t = -26,6$$
$$\therefore \Delta t = 0,013\text{s}$$

This is only a fraction of a second, but it is in accordance with our experience. We know that when a brick falls onto the ground it comes to rest almost immediately.

PROBLEM 5: CONSERVATION OF MOMENTUM (2D)

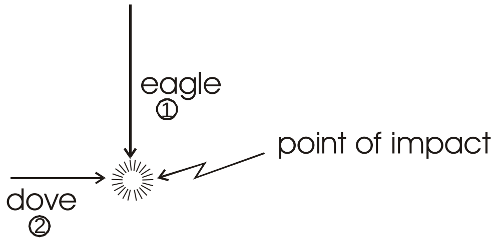
An eagle soaring high in the sky, spots a dove 30 m below, flying horizontally with a speed of 12 ms^{-1}. The eagle goes into a vertical dive and grabs the dove when it is directly below the point where the eagle went into its dive. The mass of the dove is 0,80 kg and the mass of the eagle is 2,1 kg. Assume that the initial vertical speed of the eagle is zero.

5.1 What is the speed of the eagle when it grabs the dove. Choose upwards as positive.

$$y = ut + \tfrac{1}{2}gt^2$$
$$-30 = 0 + \tfrac{1}{2}(-9,8)t^2$$
$$t = 2,5\text{s}$$
$$v = gt = -24,2 \text{ ms}^{-1}$$

5.2 Calculate the speed of the eagle just after it has grabbed the dove in its claws.

Choose a coordinate system: Positive x is to the right and positive y is upwards.



Momentum is conserved in the X- and the Y -direction:

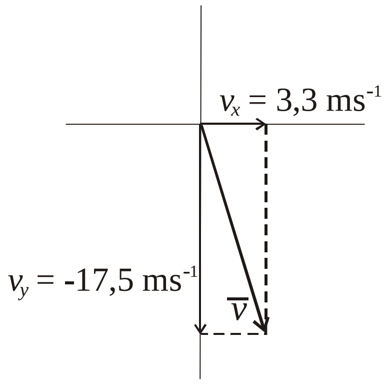
X-direction:

$$m_1u_{x1} + m_2u_{x2} = (m_1 + m_2)v_x$$
$$0 + (0{,}8)(12) = (0{,}8 + 2{,}1)v_x$$
$$\therefore \quad v_x = 3{,}3\ \text{ms}^{-1}$$

Y-direction:

$$m_1u_{y1} + m_2u_{y2} = (m_1 + m_2)v_y$$
$$(2{,}1)(-24{,}2) + 0 = (2{,}9)v_y$$
$$\therefore \quad v_y = -17{,}5\ \text{ms}^{-1}$$

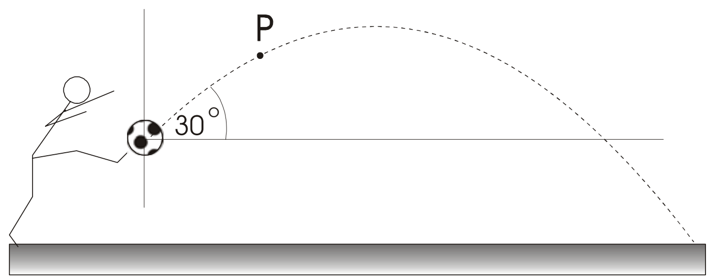
Now that we have the two components of the velocity, we can find the magnitude of the instantaneous velocity just after the eagle has grabbed the dove, which is the speed required in the question.



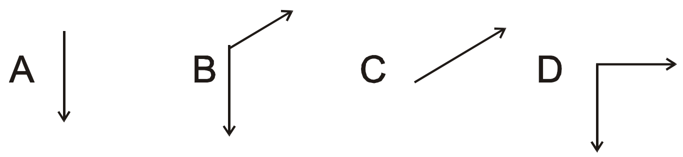
$$|\overline{v}| = \sqrt{(3{,}3)^2 + (-17{,}5)^2} = 17{,}8\ \text{ms}^{-1}$$

PROBLEM 6: PROJECTILE MOTION (2D)

A boy kicks a soccer ball and the ball leaves the boy's boot at a height of 0,80 m above the ground with a speed of 8,8 ms^{-1} at an angle of 30° with the horizontal. Ignore air friction.



6.1 Which diagram shows the direction(s) of the force(s) acting on the ball, when the ball is at point P along its trajectory?



Answer: **A** Gravity is the only force acting on the ball during its journey through the air. There are no horizontal forces acting on the ball. As soon as the ball leaves the boy's boot the force between the ball and the boot ceases to exist. The boot cannot exert a force on the ball without touching it. Someone choosing B as answer, is probably confusing force and momentum. It is true that the ball has momentum in the direction of motion, but one cannot indicated force and momentum on the same vector diagram.

Let us analyse the problem:

X-components	**Y-components**
$a_x = 0$ $v_x = v_{xi}$ (stays constant) At max. height $v_x = v_{xi}$ displacement $x = v_{xi} \times t$	$a_y = -9{,}8\ \text{ms}^{-2}$ v_y not constant At max. height $v_y = 0$ displacement: $y = v_{yi}\, t + ½\, gt^2$

6.2 Write the x- and y-components of the initial velocity.

$$v_{xi} = 8{,}8\cos 60°\ \text{ms}^{-1} = 4{,}4\ \text{ms}^{-1}$$
$$v_{yi} = 8{,}8\sin 60°\ \text{ms}^{-1} = 7{,}6\ \text{ms}^{-1}$$

6.3 Calculate the maximum height above the ground the ball reaches.

This question requires us to look at the vertical motion (y-components). When the ball reaches its maximum height $v_y = 0$.

$$v_y = v_{yi} + gt$$
$$\therefore 0 = 7{,}6 - 9{,}8t$$
$$\therefore t = 0{,}775 = 0{,}78\,\text{s}$$

$$y = v_{yi}t + \tfrac{1}{2}gt^2$$
$$\therefore y = (7{,}6)(0{,}78) + \tfrac{1}{2}(-9{,}8)(0{,}78)^2$$
$$\therefore y = 2{,}9\,\text{m}$$

The height above the ground = 2,9 m + 0,8 m = 3,7 m

6.4 Calculate how far the boy kicks the ball, that is, what distance from the boy's boot does the ball fall onto the ground.

When the bal reaches the ground $y = -0{,}80$ m. (That is 0,8 m below the point where the ball was kicked). This question asks us to find x when $y = -0{,}8$ m. First find the time it takes the ball to reach the ground.

$$y = v_{yi}t + \tfrac{1}{2}a_y t^2$$
$$-0{,}8 = 7{,}6t - \tfrac{1}{2}(9{,}8)t^2$$

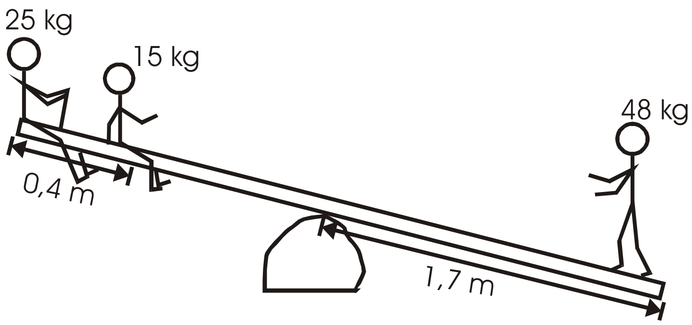
Solve for t: $t = 1{,}65\,\text{s}$

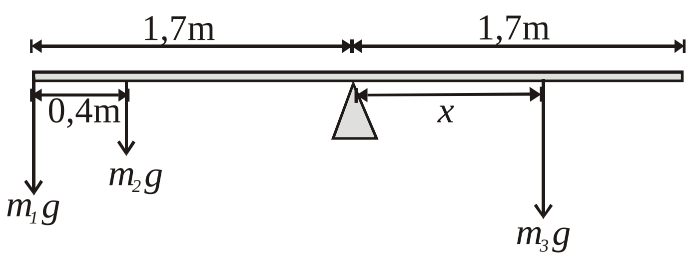
Substitute in x:

$$x = v_x t$$
$$\therefore\ x = (4{,}4)(1{,}65) = 7{,}3\,\text{m}$$

PROBLEM 7: MOMENT OF FORCE

Three children are playing on a see-saw they made by balancing a 3,4 m long plank on a rock in the middle of the plank. The plank is homogeneous and uniform. The two smallest children (with masses m_1 = 25 kg and m_2 = 15 kg) sit on the left side (0,40 m apart) as shown in the diagram. When the oldest child (mass m_3 = 48 kg) stand on the right end, that end touches the ground. How far must the oldest child walk along the plank towards the rock, so that the see-saw will balance horizontally again?





Remember: Moment of force: $\tau = F \times l$, where F is an applied force and l the distance from the point where the force is applied to the pivot point.

First draw a force diagram:

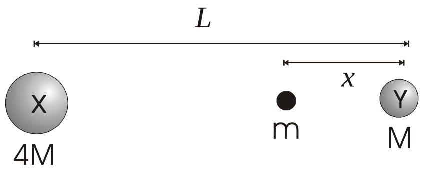
We will apply the following principle: the sum of clockwise moments = the sum of counter clockwise moments.

(We do not take the mass of the plank and the effect gravitation has on the plank into account, because the plank is homogeneous and balanced in the middle. Gravitation has therefore no moment (rotating effect) on the plank itself.)

$$m_3 gx = m_1(1{,}7) + m_2 g(1{,}3)$$
$$(\div g)$$
$$(48)x = (25)(1{,}7) + (15)(1{,}3)$$
$$\therefore \quad x = 1{,}2 \text{ m}$$
$\therefore$ distance that the oldest child will walk = 0,5 m

PROBLEM 8: GRAVITY

The distance between the centres of two spheres, X and Y, is L. The mass of X is 4 times that of Y. Where, measured from Y, is the gravitational force on an object between the spheres, equal to zero?



A. ½L B. ⅓L C. ¼L D. ⅛L

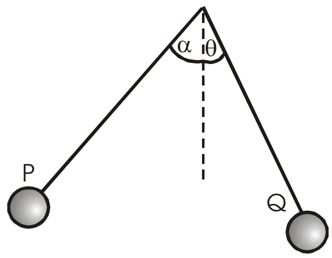
Answer: **B**
Consider the diagram: Let the mass of Y be M, then the mass of X is 4M. The mass of the other object is m. We require the force of X on m (F_{Xm}) to be equal the force of Y on m (F_{Ym}).

$$F_{Xm} = F_{Ym}$$
$$\frac{G(4M)m}{(L-x)^2} = \frac{GMm}{x^2}$$
$$4x^2 = (L-x)^2$$
$$x = \tfrac{1}{3}L$$

ELECTRICITY AND MAGNETISM

MULTIPLE CHOICE QUESTIONS

1. The diagram shows a setup where two spheres (P and Q), attached to thin strings, have been charged positively. The two angles that the strings make with the vertical are not equal. A possible reason for this is



A. The force Q exerts on P is greater than the force P exerts on Q
B. The charge on Q must be more than charge on P
C. Q must be heavier than P
D. none of the above

Answer: **C**
According to Newton's third law, the force Q exerts op P is equal in magnitude to the force P exerts on Q. Therefore A and B is wrong, because they both violate Newton's third law. The only reason why the electrostatic repulsion between the two spheres (as calculated by Coulomb's law) cannot lift Q as high as it does P, is because Q has a greater weight than P.

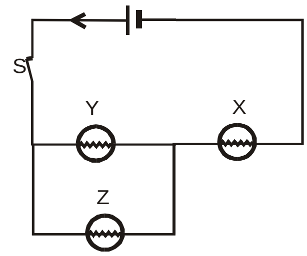
2. In which unit is the work done on charge, as it moves from one point in a circuit to another, measured?
A. Ampere
B. Volt
C. Ohm
D. Watt

Answer: **B,** $V = \frac{W}{q}$ (volt = joule/coulomb)

3. Which energy transfer is mainly taking place when charged particles move through a cell with low internal resistance?
A. chemical energy to electric potential energy
B. chemical energy to kinetic energy
C. kinetic energy to electric potential energy
D. heat to kinetic energy?

Answer: **A**

4. If all the bulbs in the circuit are identical and the resistance of the conductors and the cell is negligible, how does the brightness of bulb X compare with that of bulb Y?



A. X is brighter than Y
B. the same
C. X is dimmer than Y

Answer: **A** Y and Z will glow much dimmer than X.

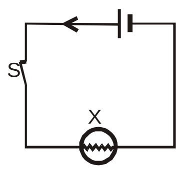
Let us assume that at the moment we compare the brightness of the bulbs, the resistances of the three bulbs are equal (see note below). Say $R = 2\ \Omega$ for all the bulbs. If the current through X is1 A, the current through Y is 0,5 A. The power in each bulb is the rate at which electrical potential energy is converted to light and heat and can be an indication of the brightness of the bulb:

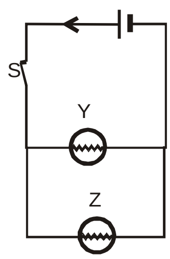
$$P_X = I^2 R = (1)^2(2) = 2\,\mathrm{W}$$

$$P_Y = (0{,}5)^2(2) = 0{,}5\mathrm{W}$$

(Note: Because X glow brighter than Y and Z, the temperature of X is higher than that of Y and Z. Since the temperature influences the resistance of a wire, the resistance of the three bulbs are probably not exactly the same as we would expect of identical bulbs)

5. If all the components in these circuits are identical and the resistance of the conductors and the cell is negligible, how does the brightness of bulb X compare with that of bulb Y?



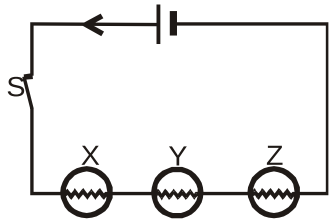


A. X is brighter than Y
B. the same
C. X is dimmer than Y

Answer: **B,** the voltage across the two bulbs is the same and they have the same resistance. The power $P = \frac{V^2}{R}$ is the same for both.

Note: Remember that the resistance of filament light bulbs are influenced by the temperature of the filament. It might happen that if you close the circuit on the left long before the other one, that particular bulb will reach a higher temperature and won't have the same resistance as the others any more. For the situation above, we assumed that the bulbs have the same resistance at the moment the comparison of brightness was done.

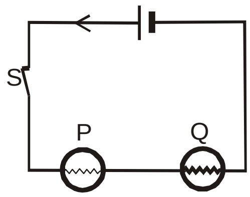
6. The diagram shows an electric circuit with three different light bulbs X, Y and Z. When switch S is closed, we find that bulbs X and Y are glowing, but not bulb Z. The reason for this is that .....

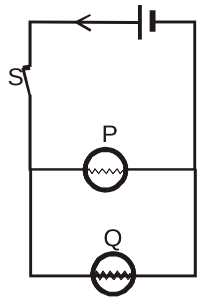


A. Z has fused
B. the resistance of Z is too low
C. the resistance for Z is too high
D. the current is to weak by the time it reaches Z

Answer: **B**, If Z has fused, the circuit will be broken and none of the bulbs will glow - so A is wrong. A bulb glows because the filament gets hot and that happens because the resistance of the filament is high. If the resistance is low the filament won't get hot and the bulb will not glow.

7. Two light bulbs, one with a thin filament (P) and the other with a thicker filament (Q) but of the same length and material as P, are connected in circuits consecutively, as shown. The cells are identical with negligible internal resistance. Compare the brightness of P with that of Q in each circuit. Choose from the table below the correct combination.

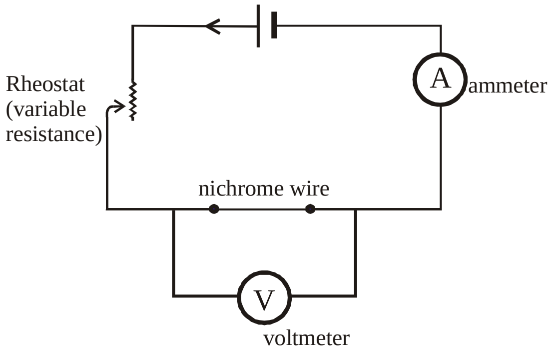




	Series circuit	**Parallel circuit**
A	P is dimmer than Q	P is dimmer than Q
B	P is dimmer than Q	P is brighter than Q
C	P is brighter than Q	P is dimmer than Q
D	P is brighter than Q	P is brighter than Q

Answer: **C.** P has a higher resistance than Q. In the series circuit the current is the same through both bulbs. Looking at $P = I^2 R$ we see that the power in the bulb with the highest resistance is the highest and therefore will glow the brightest. In the parallel circuit the potential difference across the bulbs is the same and from $P = \frac{V^2}{R}$ we see that the bulb with the highest resistance has the lowest power and will therefore glow dimmer.

8. Susan reads in her science textbook that for a certain type of resistor, the ratio of the potential difference (V) across the resistor to the current through the resistor (I) stays constant as long as the temperature of the resistor does not change. She wants to check if this is true for a piece of nichrome wire by connecting it in a circuit similar to the one in the diagram. If Susan did the investigation correctly, which one of the tables below can be a representation of her data?



A

V (volt)	I (ampere)
1,0	0,2
1,0	0,2
1,0	0,2
1,0	0,2
1,0	0,2

B

V (volt)	I (ampere)
0,50	0,10
0,95	0,19
1,45	0,28
1,70	0,35
1,90	0,38

C

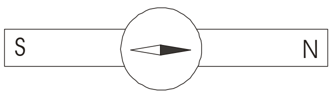
V (volt)	I (ampere)
1,1	0,20
1,0	0,19
0,9	0,21
0,9	0.20
1,0	0,21

D

V (volt)	I (ampere)
1,0	0,2
1,0	0,3
1,0	0,4
1,0	0,5
1,0	0,6

Answer: **B**

9. We place a compass right on top of a bar magnet and see that the orientation of the compass needle is as shown in the diagram.

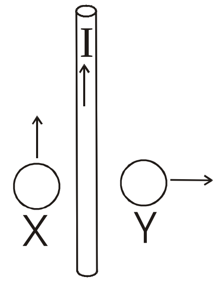


We remove the compass from the bar magnet and let the needle orientate itself in the magnetic field of the earth. In which direction will the black end of the compass needle point?

A. to the North
B. to the South
C. It depends on whether we are in the northern or southern hemisphere.

Answer: **B**. The magnetic pole in the Earth's Southern Hemisphere (near the south geographic pole) is really the north pole of the Earth's magnetic dipole.

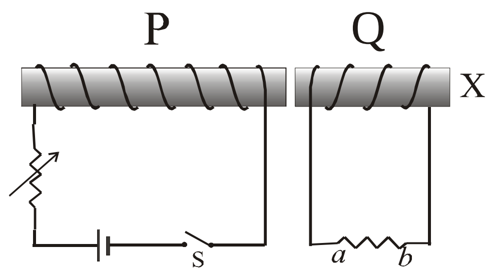
10. The diagram shows a section of a long straight conductor carrying a constant current to the top of the page. Two metal rings (X and Y) on opposite sides of the conductor are being moved in the directions shown in the diagram. The current(s) induced in the two metal rings (X and Y) can be described by



A. X: No current induced, Y: clockwise
B. X: clockwise, Y: counter clockwise
C. X: counter clockwise, Y: clockwise
D. X: No current induced, Y: counter clockwise
E. X: counter clockwise, Y: no current induced

Answer: **A**, at a constant distance from the wire, the magnetic field is constant, so there is no change in magnetic flux through loop X as it moves parallel to the wire and therefore no induced current. As loop Y moves away from the wire the field lines going into the page through loop Y decreases, and according to Lenz's law a clockwise current will be induced in Y.

11. Two sets of coils of insulated wire are wound around two cardboard tubes and connected in circuits as shown in the diagram. A student is experimenting with this by changing something in the setup to create different situations. She also uses a compass to see what the induced magnetic pole at X will be.



Situation (i): Coil P is being moved towards the left, while S is closed.
Situation (ii): By means of the rheostat, the resistance in circuit P is gradually increased

Decide in each situation what the induced magnetic pole at X will be.

	Situation (i)	Situation (ii)
A	North	North
B	South	South
C	North	South
D	South	North

Answer: **A**

12. Magnets attract
   A. only iron, nickel and cobalt
   B. all metals except aluminum
   C. all metals
   D. only steel

   Answer: **A**

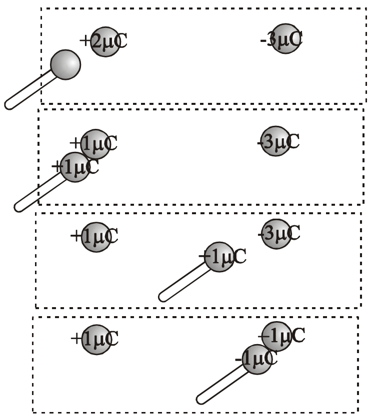
PROBLEM 1: COULOMB'S LAW

Two small conducting spheres (A and B) are charged with +2,0 μC and -3,0 μC respectively and placed at a distance of 5,0 cm from each other and experience an attractive force F. A third uncharged, conducting sphere with an insulating handle is brought into contact with the first sphere (A) and then, without touching anything else, brought into contact with B. By which distance should A and B be separated now, to experience the same force of attraction, F, between them as before?

First find the initial force of attraction between the spheres.

$$F = \frac{kq_1q_2}{r^2}$$
$$F = \frac{(9 \times 10^9)(2 \times 10^{-6})(3 \times 10^{-6})}{(0{,}05)^2}$$
$$F = 21{,}6\,\mathrm{N}$$

Find out what the final charges on the spheres will be after contact with the third sphere. See the diagram.

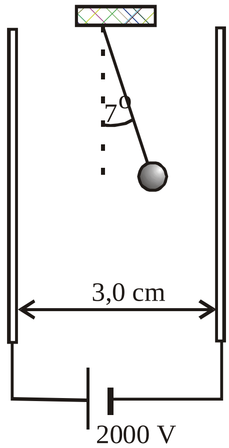


We see that the final charges on the two spheres are +1,0 μC and -1,0 μC. The attractive force between them must be 21,6 N as required by the question.

$$21{,}6 = \frac{(9 \times 10^9)(10^{-6})(10^{-6})}{r^2}$$
$$\therefore\ r = 0{,}0204\ \mathrm{m}$$
$$\therefore\ r = 2{,}0\,\mathrm{cm}$$

PROBLEM 2: A CHARGED PARTICLE IN A UNIFORM FIELD

A small, charged sphere is suspended on a very light string between two oppositely charged parallel plates, as shown in the diagram. The plate separation is 3,0 cm and the potential difference between the plates is 2000 V. The mass of the sphere is 8,0 g and the angle between the string and the vertical is 7,0°.



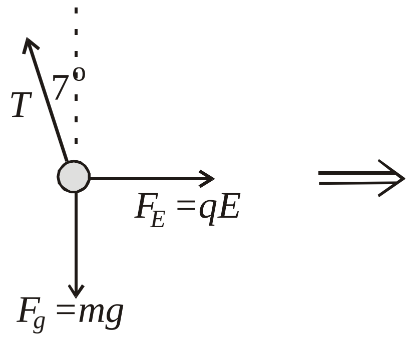
2.1 Calculate the electric field between the plates.

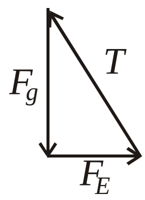
$$E = \frac{V}{d}$$

$$\therefore\ E = \frac{2000}{0,03} = 6,67 \times 10^4\ \text{Vm}^{-1}$$

3.2 Calculate the charge on the sphere. Give the answer in nC.

The forces acting on the sphere are in equilibrium.



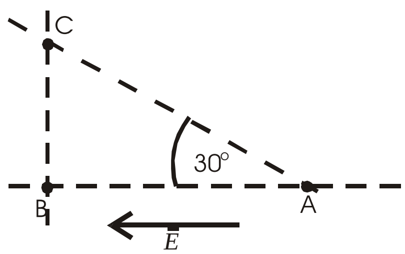


$$F_E = F_g \tan 7°$$
$$= (0,008)(9,8) \tan 7°$$
$$= 9,63 \times 10^{-3}\,\text{N}$$

$$\therefore qE = 9,63 \times 10^{-3}\,\text{N}$$
$$\therefore q = 1,44 \times 10^{-7}\,\text{C} = 144\,\text{nC}$$

PROBLEM 3: WORK AND ENERGY IN AN ELECTRIC FIELD

A particle with mass $3,00 \times 10^{-23}$ kg and charge + 1,50 nC moves in a uniform field from rest from point A to point B where its speed is found to be $2,00 \times 10^{6}$ ms^{-1}. Point A and point B are separated by 5,00 cm.



3.1 How much work is done on the particle by the field?

$$W = \Delta E_k = E_{kB} - E_{kA}$$
$$= \tfrac{1}{2} m v_B^2 - 0$$
$$= \tfrac{1}{2}(3 \times 10^{-23})(2 \times 10^{6})^2$$
$$= 6{,}0 \times 10^{-11}\ \text{J}$$

3.2 Find the potential difference between points A and B and explain what the answer means in terms of the definition of potential difference.

$$V_{AB} = \frac{W_{A \to B}}{q} = \frac{6 \times 10^{-11}}{1{,}5 \times 10^{-9}} = 0{,}04\ \text{V}$$

This means that 0,04 joules of work is done (by the field) per unit charge to move the charged particle from point A to point B.

3.3 Find the magnitude of the electric field.

$$E = \frac{V}{d} = \frac{0{,}04}{0{,}05} = 0{,}8\ \text{Vm}^{-1}$$

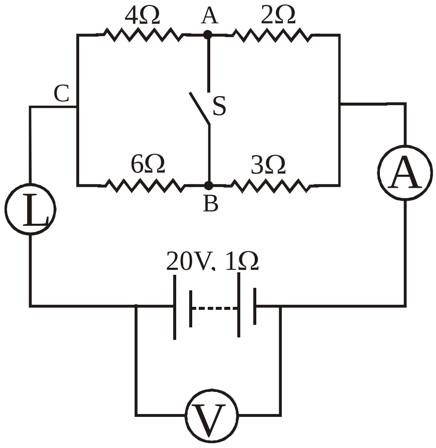
3.4 An identical particle is moved by an external force from point C to point A. How much work is done by this force? Explain your answer.

$$W = 6{,}0 \times 10^{-11}\ \text{J}$$

Since the field is uniform, point B and point C are at the same electric potential. It means that a given charged particle will have the same electrical potential energy at C than is has at B and therefore the same amount of work will be done to take a particle from C to A as will be done by the field to take the particle from A to B.

PROBLEM 4: ELECTRIC CIRCUIT

A circuit is connected as shown in the diagram. The lightbulb L has a resistance of 0,4Ω. The effect the temperature has on the resistance of the lightbulb can be ignored.



4.1 With switch S open, determine the effective resistance, R_{eff}, of the circuit, battery included.

For the parallel combination: $$\frac{1}{R} = \frac{1}{4+2} + \frac{1}{6+3} = \frac{5}{18}$$

$$\therefore R_{parallel} = 3{,}6\,\Omega$$

$$R_{eff} = 3{,}6 + 0{,}4 + 1 = 5\Omega$$

4.2 Calculate the reading on the ammeter with S still open.

$$I = \frac{V}{R} = \frac{20}{5} = 4\,\text{A}$$

4.3 Calculate the reading on the voltmeter with S still open.

The reading on the voltmeter gives the amount of energy that is available to the circuit per unit charge that leaves the battery. If the battery had no internal resistance all 20 joules of energy (per unit charge) would be available to the rest of the circuit. But now, because of the internal resistance, some of the energy is converted to heat right inside the battery and is not available to the circuit. This amount is often called the "lost volts".

So, the voltmeter reading is equal to the total amount of energy that the battery can provide (per unit charge), that is the emf (ε), minus the energy converted to heat before the charge left the battery, that is Ir.

$$V = \varepsilon - Ir$$

$$\therefore V = 20 - (5)(1) = 15\,\text{V}$$

4.4 With S still open, determine the potential difference (voltage) between A and B.

Voltage across the parallel combination: $V = IR = (4)(3{,}6) = 14{,}4$ V
Now we can calculate the currents through the top and bottom branches of the parallel section.

$$\therefore I_{top} = \frac{14{,}4}{(4+2)} = 2{,}4\text{ A} \quad \text{and} \quad I_{bottom} = \frac{14{,}4}{(6+3)} = 1{,}6\text{ A}$$

$$\therefore V_{CA} = I_{CA}R = (2{,}4)(4) = 9{,}6\text{ V} \quad \text{and} \quad V_{CB} = I_{CB}R = (1{,}6)(6) = 9{,}6\,\text{V}$$

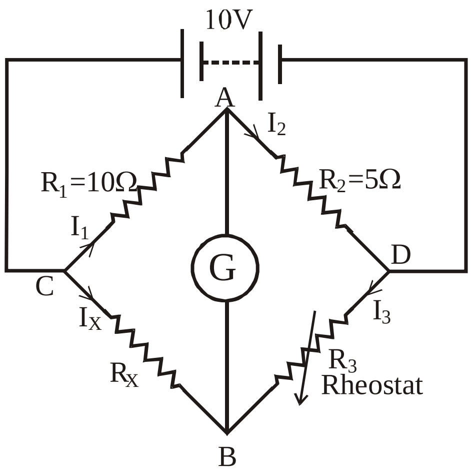
Thus, the potential at A is equal to the potential at B and there is no potential difference between A and B. $V_{AB} = 0$ V.

4.5 Switch S is now closed. What will be the effect on the brightness of the lightbulb?

No effect, since there was no potential difference between a and B, no current will flow from A to B when the switch is closed and the current in the circuit will not be affected.

PROBLEM 5: THE WHEATSTONE BRIDGE

The Wheatstone bridge is a device used to measure resistance very accurately. With the setup below we want to measure the resistance of R_X. At first we see that the galvanometer registers a current between A and B when the rheostat is set at 6Ω.



5.1 What should be done to be able to measure the resistance of R_X?

We should vary the resistance of the rheostat until no current registers on the galvanometer. When that is the case, we know that $V_{AB} = 0$ or $V_A = V_B$, and therefore $V_{CA} = V_{CB}$ and $V_{AD} = V_{BD}$. Thus

$$I_1 R_1 = I_X R_X$$

$$\text{and} \quad I_2 R_2 = I_3 R_3$$

$$\therefore \quad \frac{I_1 R_1}{I_2 R_2} = \frac{I_X R_X}{I_3 R_3}$$

But if there is no current between A and B, then $I_1 = I_2$ and $I_X = I_3$

$$\therefore \quad \frac{R_1}{R_2} = \frac{R_X}{R_3}$$

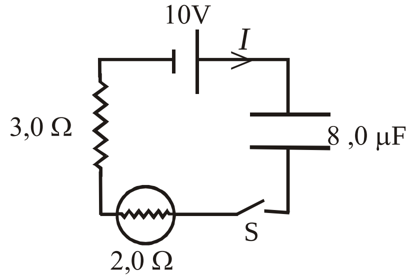
$$\therefore \quad R_X = \frac{R_1 R_3}{R_2}$$

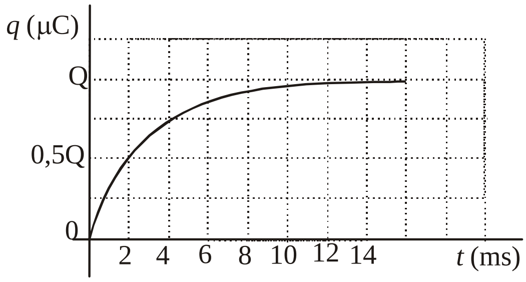
5.2 If we set the rheostat to 8Ω, we see that the reading on the galvanometer is zero. Find the resistance of R_X.

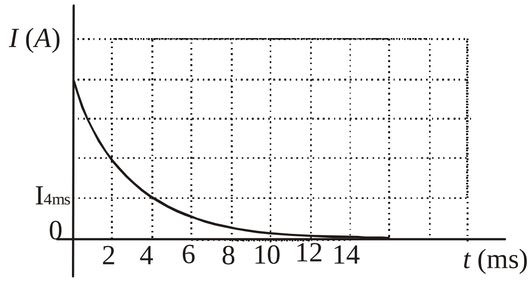
$$R_X = \frac{(10)(8)}{5} = 16\,\Omega$$

PROBLEM 6: THE RC-CIRCUIT

The capacitor in the circuit, with a capacitance of 8,0 μF, will be fully charged after 12,0 ms from the instant the switch is closed. Included in the circuit is a resistor of 3,0 Ω and a lightbulb with a resistance of 2,0 Ω. The internal resistance of the cell can be ignored. Study the graphs and answer the questions below.







6.1 Calculate the value of Q indicated on graph on the left.

Q is the charge on the capacitor when it is fully charged. When the capacitor is fully charge, the current in the circuit is zero and so, the potential differences across the resistance and the lightbulb are also zero. The potential difference across the capacitor is therefore 10 V.

$$\therefore \quad Q = CV = (8\mu F)(10V) = 80\mu C$$

6.2 Calculate the value of I at 4 ms, indicated on the graph on the right.

First find the initial (maximum) value of the current. At $t = 0$ s the charge on and the voltage across the capacitor is zero. Thus, the voltage across the resistors is 10 V.

$$I = \frac{V}{R} = \frac{10}{5} = 2 \text{ A}$$

The value of I at 4 ms is one quarter of the initial, maximum value, $\therefore I_{4\text{ms}} = 0{,}5$ A.

6.3 Calculate the power in the bulb at 4 ms.

$$P = I^2 R = (0{,}5)^2 2 = 0{,}5\text{W}$$

6.4 What would be the area of the plates if the plate separation is 5 mm.

$$C = \frac{\varepsilon_0 A}{d}$$

$$8 \times 10^{-6} = \frac{(8{,}85 \times 10^{-12})(A)}{0{,}005}$$

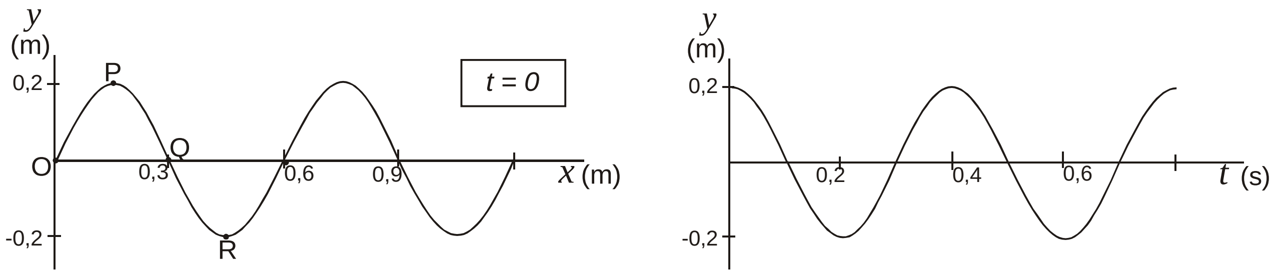
$$\therefore \quad A = 4{,}5 \times 10^3 \text{ m}^2$$

We see that this is an immense area for a circuit component. In reality, parallel plates are not used in circuits, but rather cylindrical capacitors which are basically two parallel plates separated by a insulating material, wound up tightly in a cylinder.

WAVES, SOUND AND LIGHT

PROBLEM 1: TRANSVERSE WAVES

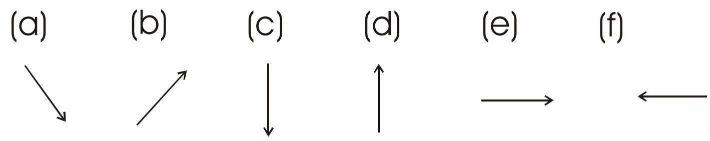
The figure shows two graphs for one and the same wave motion in a given string. The wave is moving towards the right. The first graph shows the vertical displacement of the string as a function of the position of the particles in the string at time t = 0. The second graph shows the vertical displacement of only one of the particles in the string as a function of time .



1.1 What are the amplitude, wavelength, the period, the frequency and the speed of the wave?

Amplitude: $A = 0{,}2$ m
Wavelength: $\lambda = 0{,}6$ m (read from the graph on the left)
Period: $T = 0{,}4$ s (read from the graph on the right)
Frequency: $f = 1/T = 2{,}5$ Hz
Wave speed: $v = f\lambda = 1{,}5\ \text{ms}^{-1}$

1.2 For each of the points O, P, Q and R on the graph on the left, choose from the possibilities below, a direction in which that particular point will be moving immediately after t = 0.



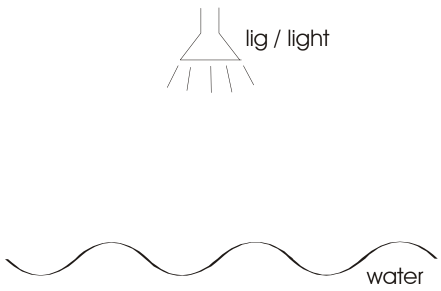
Answer: point O (c); point P (c); point Q (d); point R (d)
This graph can be seen as a snapshot of the string at a certain instant. Every particle in the string is oscillating vertically up and down as the wave travels towards the right in the string. The a wave does not transfer particles from one point to another in the direction of motion of the wave.

1.3 Of which point (O, P, Q or R) is the other diagram a position - time graph? Explain your choice.

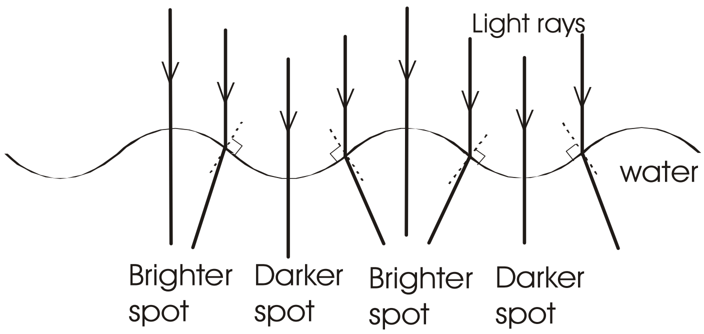
Answer: P. On the instant for which the first graph is drawn, point P has already reached its maximum displacement and will start moving downwards (see question 1.2). This corresponds to the position-time graph showing a particle starting at its maximum displacement and moving downwards.

PROBLEM 2: WAVES IN A RIPPLE TANK

In a ripple tank light is shone from above on shallow water in which little wavelets are made. The diagram shows a side view of the wavelets. The pattern of light and shadowy lines (or circles) that is formed on a white surface below the ripple tank, is a result of the wave pattern. Does a shadowy line correspond to a crest or a trough in the water wave? Explain.



The best way to explain this is to draw a ray diagram indicating the direction of the light rays after refraction at the surface of the water. When light rays travel from an optical less dense medium to a denser medium the rays refract towards the normal. (Remember: the normal is an imaginary line perpendicular to the interface between the two mediums). When a light ray enters the medium along a line perpendicular to the surface it goes through undeflected.

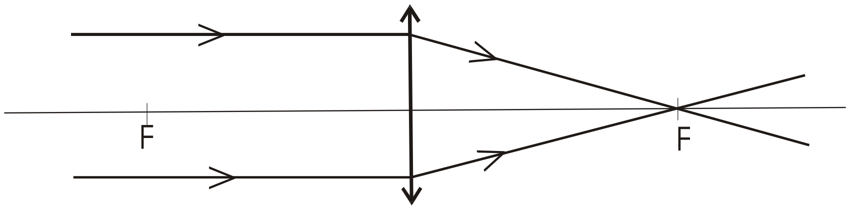


Darker (or shadowy) spots will form if most light rays are directed away from that spot. So we see that the brighter lines form underneath the crests and the shadowy (or darker lines) form underneath the troughs.

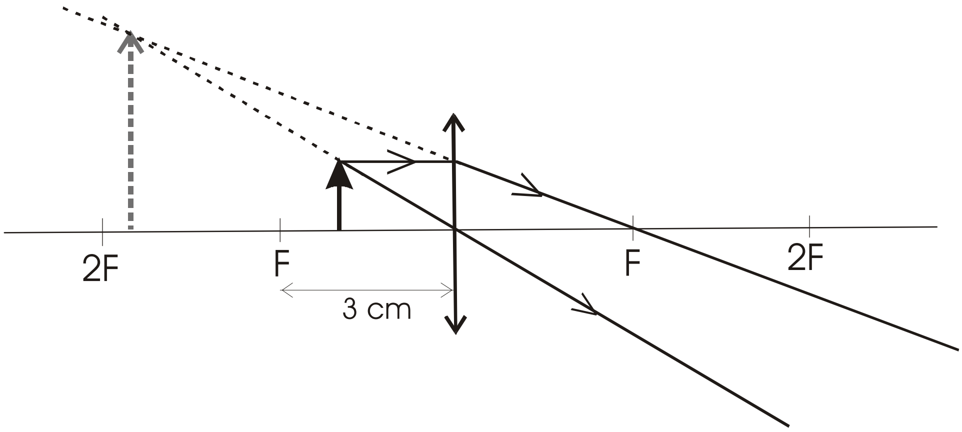
PROBLEM 3: LENSES

Use ray diagrams to indicate image formation in the following cases: Use the symbol ↕ to indicate a convex lens.

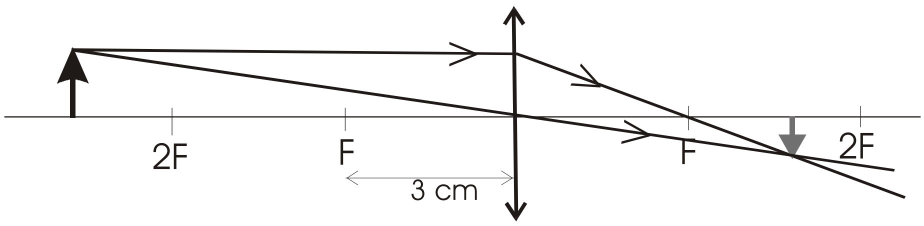
3.1 A convex lens with focal length 5 cm, with light rays coming from a very distant source.
Light rays coming from a very distance source can be considered as being parallel to the main axis.



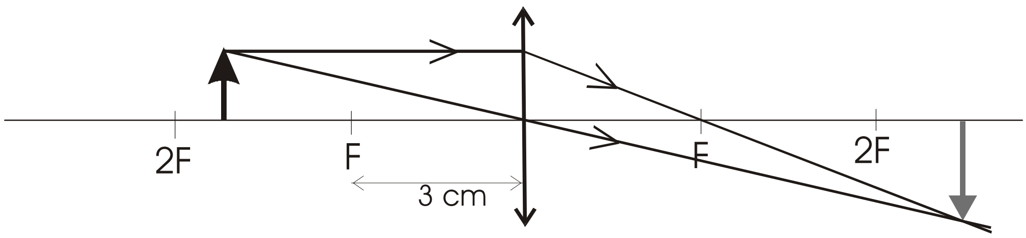
3.2 A convex lens with focal length 3 cm with an object 2 cm to the left of the lens.



3.3 A convex lens with focal length 3 cm with an object 8 cm to the left of the lens.

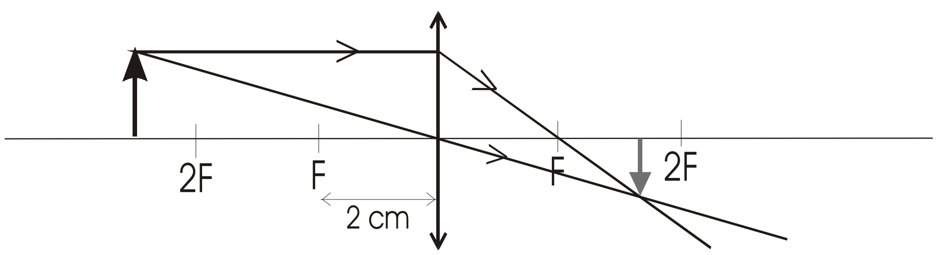


3.4 A convex lens with focal length 3 cm with an object 5 cm to the left of the lens.



3.5 A convex lens with focal length 2 cm with an object 5 cm to the left of the lens. Also say how a lens with shorter focal length differ from a lens with longer focal length.

When a lens has a shorter focal length it is more curved than a lens with a longer focal length.



3.6 Which case above corresponds to:

(i) using a magnifying glass to examine a small object

(ii) burning a hole in a dry leaf using a magnifying glass ,

(iii) image formation in the eye.

Explain your answers.

(i) **3.2** In this case we see a magnified, upright image as is required when we examine small objects with a magnifying glass. We see that if we want to use a lens as a magnifying glass, the object must be between the lens and the focal point.

(ii) **3.1** The sun is a very distant object and the rays from the sun can be considered as falling in parallel to the main axis. The sun's rays will converge in the focal point and the intensity will be high enough to burn something like a dry leaf.

(iii) **3.3 to 3.5** The cornea and the lens of the eye converges light coming from objects further away from the eye than its focal point. The image that forms on the retina is real, inverted and much smaller than the object. (The retina is the light sensitive "film" at the back of the eye on which the images form.)

3.7 Use diagrams 3.3 to 3.5 to explain the function of the lens and eye muscles in the eye.

One should note that we can only see something clearly if the image forms exactly on the retina. If the image forms behind or in front of the retina we will perceive an out of focus or blurred image. The distance between the eye lens and the retina is constant. Thus, if the lens could not adapt in some way to the distance the object is in front of the eye, most of the images will not from exactly on the retina.

When comparing diagrams 3.3 and 3.4 we see that the closer an object is to the lens (provided it is still further away from the lens than the focal point) the further away the image is from the lens. Suppose that 3.3 represents an object distance that is exactly right for a specific eye lens and that the image forms on the retina. If the object now comes closer (as in diagram 3.4) the image will move further away from the lens and form behind the retina.

Now compare diagrams 3.4 and 3.5. Here we see that for a lens with a shorter focal distance the image will form closer to the lens for the same object distance. So, if the lens could become more curved (and have a shorter focal length) when the object is closer to the eye, the image could form exactly on the retina again. This is what the lens muscles do; when an object is close to the eye, the lens muscles contract and in doing so increase the curvature of the lens so that the image still forms on the retina.

When a person gets older, it often happens that the lens muscles lose their ability to contract and therefore the lens cannot become curved enough for the person to be able to focus on nearby objects and they often need to wear glasses with convex lenses to compensate for the lack of curvature of their own eye lenses.

PROBLEM 4: DOPPLER EFFECT

The sound source of a ship's sonar device operates at a frequency of 30 kHz. A submarine is travelling directly away from the ship with a speed of 24 ms^{-1}. The ship is at rest in the water and sends out a signal which reflects at the moving submarine. After the signal has reflected at the submarine it is detected by the sonar device on the ship. The speed of sound in water is 1480m/s.

4.1 Calculate the frequency of the soundwave as it will be detected by a device on the submarine.

$$f_L = \frac{v - v_L}{v - v_s} f_s$$

Treat the submarine in this part of the problem as the "listener" L and the ship as the source S. We need to calculate f_L. (Also remember that v_L and v_S is positive when L and/or S move in the same direction as the sound and negative when they move in the opposite direction as the sound.)

$$f_S = 30\,\text{kHz}$$
$$v_L = +24\,\text{ms}^{-1}$$
$$v_S = 0$$
$$f_L = ?$$

$$f_L = \left(\frac{1480 - 24}{1480}\right)30 = 29{,}5\,\text{kHz}$$

4.2 Calculate the frequency that is detected by ship's sonar device after the reflected signal has arrived at the ship.

In this part of the problem, we treat the submarine as the source, because the sound signal now comes from the submarine. The frequency of the reflected signal is f_S. Here v_S is negative, because the sound is travelling towards the ship, but the submarine is travelling away from the ship.

$$f_L = ?\ \text{(the signal detected by the ship)}$$
$$f_S = 29{,}5\,kHz \quad \text{(the frequency reflected at the submarine} = f_L \text{ of 4.1)}$$
$$v_L = 0$$
$$v_S = -24\,ms^{-1}$$

$$f_L = \frac{1480}{1480 + 24} 29{,}5 = 29{,}0\,\text{kHz}$$

By comparing the outgoing signal with the reflected signal a ship can determine the speed of another vessel moving in its vicinity.

INHOUDSOPGAWE

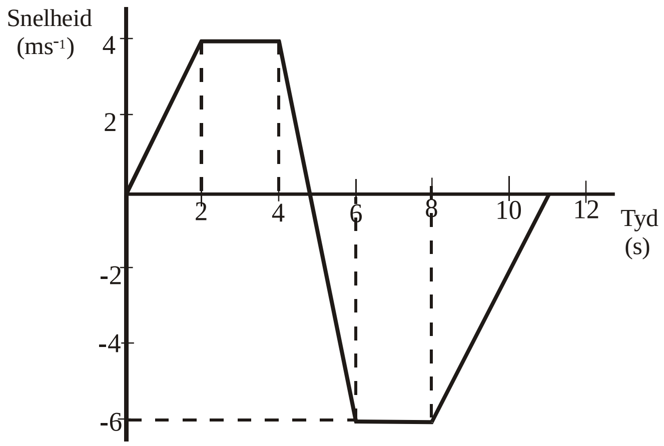
MEGANIKA

ALGEMENE INLIGTNG:

- In hierdie studiegids word die waarde van gravitasieversnelling deurgaans geneem as 9,8 ms^{-2}.
- Ons gebruik die onderskrif i vir beginwaardes van 'n sekere interval en f vir die finale waardes van die interval. Byvoorbeeld is v_i die beginsnelheid van 'n sekere interval (in plaas van u wat in sommige handboeke gebruik word) en v_f is dan die eindsnelheid van die interval (in plaas van net v wat in sommige handboeke gebruik word).

PROBLEEM 1: BEWEGINGSGRAFIEKE

Die pad van 'n bewegende deeltjie is beperk tot 'n reguitlyn wat noord-suid loop. Kies 'n assestelsel waarin noord positief is. Die grafiek hieronder gee die snelheid as funksie van tyd. Die grafiek sny die horisontale as by 4,8 s en 11 s.



1.1 Voltooi 'n tabel waarin jy aandui wat die rigtings is van die snelheid (in een kolom) en die versnelling in 'n ander kolom vir die volgende tydstippe: 1,0s, 3,0s, 4,2s, 5,0s, 7,0s, 10,0s. Dui in 'n derde kolom aan of die voorwerp stadiger, vinniger of teen 'n konstante spoed beweeg.

tyd	snelheid	versnelling	vinniger/stadiger
1,0s	Noord (+)	Noord (+)	vinniger
3,0s	Noord (+)	nul	konstante spoed
4,2s	Noord (+)	Suid (-)	stadiger
5,0s	Suid (-)	Suid (-)	vinniger
7,0s	Suid (-)	nul	konstante spoed
10s	Suid (-)	Noord (+)	stadiger

1.2 Wat is die totale verplasing van die voorwerp gedurende die reis?

Bepaal die oppervlak (area) onder die grafiek. (Die oppervlakke onder die x-as is negatief.)

$$\text{Area} = \tfrac{1}{2}(2)(4) + (2)(4) + \tfrac{1}{2}(0{,}8)(4) - \tfrac{1}{2}(1{,}2)(6) - (2)(6) - \tfrac{1}{2}(3)(6)$$
$$= -11\,\text{m}$$

1.3 Wat is die gemiddelde snelheid vir die hele reis?

Definisie van snelheid: snelheid = verplasing ÷ tyd

$$\vec{v} = \frac{\Delta x}{\Delta t} = \frac{-11\text{m}}{11\text{s}} = -1{,}0\ \text{ms}^{-1}$$

1.4 Wat is die versnelling

1.4.1. gedurende die eerste twee sekondes?

1.4.2 tussen $t = 4\text{s}$ en $t = 6\text{s}$?

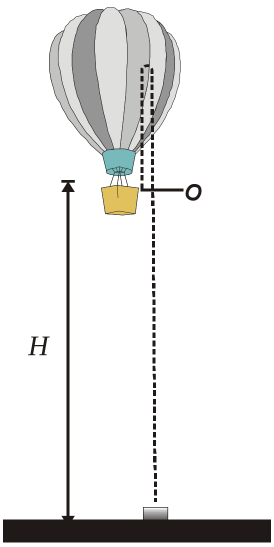
Bereken die helling van die snelheid-tyd grafiek

1.4.1 $a = \frac{\Delta v}{\Delta t} = \frac{4-0}{2-0} = 2\,ms^{-2} \quad \therefore 2\,ms^{-2}, noord$

1.4.2 $a = \frac{\Delta v}{\Delta t} = \frac{-6-4}{6-4} = -5ms^{-2} \quad \therefore 5ms^{-2}, suid$

PROBLEEM 2: VRYVAL BEWEGING

'n Warmlugballon is besig om op te styg op teen 'n spoed van 5,00 ms^{-1}. 'n Persoon in die mandjie laat 'n sakkie meel los op 'n hoogte H. Die meelsak tref die aarde met 'n spoed van 18,0 ms^{-1}.



2.1 Hoe lank sal die sakkie in die lug wees?

Kies 'n assestelsel met die oorsprong (O) by die punt waar die sakkie vrygelaat word en kies die positiewe Y-as opwaarts. Onthou, al die hoeveelhede in die bewegingsvergelykings (behalwe tyd) is vektore, daarom moet ons onthou om die tekens van hierdie hoeveelhede ook in te vervang. Daar is twee maniere om hierdie probleem op te los:

Metode 1

Deel die beweging op in drie dele: ① opwaarts tot by die maksimum hoogte, ② van die maksimum hoogte afwaarts tot by die oorsprong, en ③ van die oorsprong af afwaarts tot op die grond.

①Vir die opwaartse beweging:

$g = -9{,}8\,ms^{-2}$ $\qquad v_f = v_i + gt$

$v_i = +5{,}0\,ms^{-1}$ $\qquad \therefore 0 = 5 - 9{,}8t$

$v_f = 0$ $\qquad \therefore t_1 = 0{,}51\text{s}$

②vir die afwaartse beweging vanaf die maksimum hoogte tot by die oorsprong:

$$v_i = 0$$
$$v_f = -5{,}0\,\text{ms}^{-1}$$
$$\therefore t_2 = 0{,}51\,\text{s (dieselfde as vir 1)}$$

③Van die oorsprong af tot op die grond:

$$a = g = -9{,}8\,\text{ms}^{-2}$$
$$v_i = -5{,}0\,\text{ms}^{-1}$$
$$v_f = -18\,\text{ms}^{-1}$$

$$v_f = v_i + at$$
$$\therefore -18 = -5 - 9{,}8t$$
$$\therefore t_3 = 1{,}33\,\text{s}$$

Totale tyd $= t_1 + t_2 + t_3$
$= 0{,}51 + 0{,}51 + 1{,}33$
$= 2{,}35\ \text{s}$

Metode 2

Deel nie die beweging op in dele nie, maar beskou die beweging as 'n geheel.

$$a = g = -9{,}8\,\text{ms}^{-2}$$
$$v_i = 5\,\text{ms}^{-1}$$
$$v_f = -18\,\text{ms}^{-1}$$

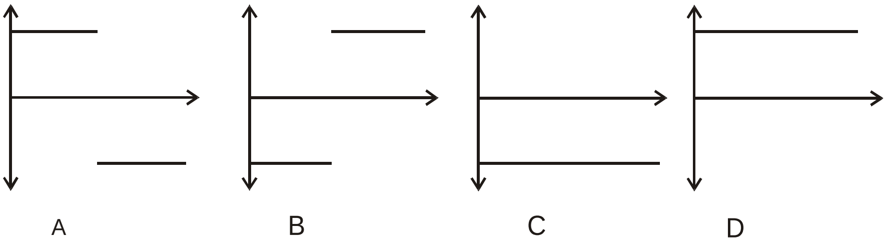
$$v_f = v_i + at$$
$$\therefore -18 = 5 - 9{,}8t$$
$$\therefore t = 2{,}35\,\text{s}$$

2.2 Bepaal H, die hoogte waarop die persoon die sakkie laat los het. Beskou weer die beweging as 'n geheel.

$$v_i = 5\,\text{ms}^{-1}$$
$$a = -9{,}8\,\text{ms}^{-2}$$
$$t = 2{,}35\,\text{s}$$

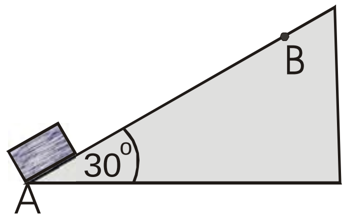
$$s = v_i t + \tfrac{1}{2}at^2$$
$$= (5)(2{,}35) + \tfrac{1}{2}(-9{,}8)(2{,}35)^2$$
$$= -15{,}3\,\text{m}$$
$$\therefore H = 15{,}3\,\text{m}$$

2.3 Watter een van die grafieke hieronder stel die versnelling-tyd grafiek vir hierdie beweging voor?



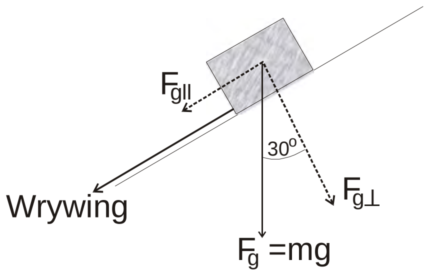
Antwoord: **C**. A en B is verkeerd, omdat hulle impliseer dat die rigting van die versnelling verander nadat die sakkie sy maksimum hoogte bereik het, wat natuurlik nie waar is nie. Gravitasie versnelling is altyd afwaarts. Vir ons keuse van assestelsel met die negatiewe y-as afwaarts, is die regte versnelling-tyd grafiek C.

PROBLEEM 3: ARBEID EN ENERGIE



'n Blokkie word by die onderkant van 'n skuinsvlak geskop (by punt A) sodat dit opwaarts begin gly met 'n beginspoed van 2,9 ms^{-1}. Die massa van die blokkie is 3,1 kg. 'n Wrywingskrag van 6,5 N werk in op die blokkie. Die blokkie kom tot rus by punt B.

3.1 Teken 'n kragtediagram om die kragte te toon wat op die blokkie inwerk terwyl dit opwaarts beweeg.



3.2 Bereken die totale arbeid wat op die blok verrig is.

Onthou: $W_{tot} = \Delta E_k$ (dit is altyd waar)

$$W_{tot} = E_{kf} - E_{ki}$$
$$= 0 - \tfrac{1}{2}mv_i^2$$
$$= -\tfrac{1}{2}(3{,}1)(2.9)^2$$
$$= -13\,\text{J}$$

3.3 Bereken die komponent van die resulterende krag op die blok, ewewydig aan die vlak.

$$F_{res} = F_{friction} + F_{gll}$$
$$= 6{,}5 + mg\sin 30^\circ$$
$$= 21{,}7\,\text{N}$$

3.4 Bereken hoe ver die blok teen die vlak sal opbeweeg.

Definisie van arbeid: $W = F.\,\Delta x$

Beide F en Δx is vektore, daarom moet ons tekens insluit om hulle rigtings aan te dui. Kies 'n assestelsel met die x - as parallel aan die skuinsvlak met die positiewe as opwaarts langs die vlak.

$\therefore F$ = -21,7 N en Δx is positief

$$W = F.\Delta x$$
$$-13 = (-21{,}7)\Delta x$$
$$\therefore \Delta x = 0{,}60\text{ m} = \text{die afstand AB}$$

PROBLEEM 4: ENERGIEBEHOUD

'n Baksteen met massa 1,2 kg word van 'n gebou, 25 m hoog, afgegooi met 'n afwaartse spoed van 1,1 ms^{-1} . Wanneer dit op die aarde val, dring dit 15 cm in die grond in. Ignoreer lugwrywing.

4.1 Bereken die spoed waarmee die baksteen die grond tref. (Let wel: Probleme soos dié kan met bewegingsvergelykings opgelos word of deur energiebeginsels. Ons gebruik energiebehoud vir hierdie probleem.)

Totale meganiese energie by bopunt = Totale meganiese energie by onderpunt
(Dit is waar omdat ons lugwrywing ingnoreer)

$$\text{Tot } E_{\text{meg bo}} = \text{Tot } E_{\text{meg onder}}$$

$$\therefore (E_k + E_p)_{bo} = (E_k + E_p)_{onder}$$

$$\therefore \tfrac{1}{2} m v_{bo}^2 + mgh = \tfrac{1}{2} m v_{onder}^2 + 0$$

$$\therefore \tfrac{1}{2} v_{bo}^2 + gh = \tfrac{1}{2} v_{onder}^2$$

$$\tfrac{1}{2}(1{,}1)^2 + (9{,}8)(25) = \tfrac{1}{2} v_{onder}$$

$$\therefore v_{onder} = 22{,}2 \text{ ms}^{-1}$$

Let op dat die massa in die vierde stap uitkanselleer. Dit beteken dat, al sou die baksteen 'n ander massa hê, die eindspoed nog steeds dieselfde sal wees.

4.2 Bereken die totale arbeid verrig op die baksteen wanneer dit die grond binnedring.

$$W_{tot} = \Delta E_k = E_{kf} - E_{ki}$$

Omdat dit tot rus kom in die grond is $E_{kf} = 0$.

$$W_{tot} = -\tfrac{1}{2} m v_i^2 = -(1{,}2)(22{,}2)^2 = -296 \text{J}$$

4.3 Bereken die wrywingskrag wat deur die grond op die baksteen uitgeoefen word om dit tot rus te bring. (Neem afwaarts as negatief)

$$W_{tot} = F_{res} . \Delta x$$

$$-296 = F_{res}(-0{,}15)$$

$$\therefore F_{res} = 1973 \text{ N}$$

Hierdie F_{res} bestaan uit bydraes deur gravitasie F_{g} (afwaarts) en wrywing F_f (opwaarts).

$$-F_g + F_f = F_{res}$$

$$-mg + F_f = 1973$$

$$F_f = 1973 + (1{,}2)(9{,}8) = 1985 \text{ N}$$

4.4 Bereken die verandering in momentum van die baksteen van die oomblik wat dit die grond tref totdat dit tot stilstand kom. (Neem afwaarts as negatief.)

$$F_{res}.\Delta t = \Delta p$$
$$\therefore\ (1973)\Delta t = 26{,}6$$
$$\therefore\quad \Delta t = 0{,}013\,\text{s}$$

4.5 Bereken die tyd wat dit neem vir die baksteen om tot rus te kom van die oomblik wat dit die grond tref.

$$\text{Impuls} = \text{verandering in momentum}$$

$$\Delta p = mv_f - mv_i$$
$$= 0 - (1{,}2)(-22{,}2)$$
$$= 26{,}6\ \text{kgms}^{-1}$$

Dit is net 'n breukdeel van 'n sekonde, maar dit stem ooreen met ons ervaring. Ons weet dat wanneer 'n baksteen op die grond val, dit feitlik onmiddelik tot rus kom.

PROBLEEM 5: BEHOUD VAN MOMENTUM (2D)

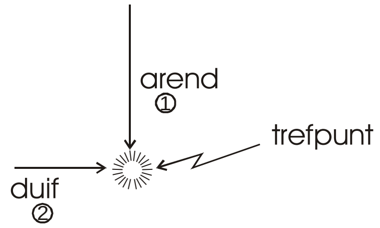
'n Arend wat hoog in die lug sweef, sien 'n duif wat 30 m onder hom horisontaal vlieg teen 'n spoed van 12 ms^{-1}. Die arend duik vertikaal af en gryp die duif wanneer dit reg onder die punt is waar hy begin duik het. Die massa van die duif is 0,80 kg en die massa van die arend is 2,1 kg. Aanvaar dat die vertikale beginspoed van die arend nul is.

5.1 Wat is die spoed van die arend wanneer dit die duif gryp. Kies opwaarts as positief.

$$y = ut + \tfrac{1}{2}gt^2$$
$$-30 = 0 + \tfrac{1}{2}(-9{,}8)t^2$$
$$t = 2{,}5\text{s}$$
$$v = gt = -24{,}2\ \text{ms}^{-1}$$

5.2 Bereken die spoed van die arend net nadat dit die duif in sy kloue gegryp het.

Kies 'n assestelsel: Positief x is na regs en positief y is opwaarts.



Momentum is behoue in die X- en die Y -rigting:

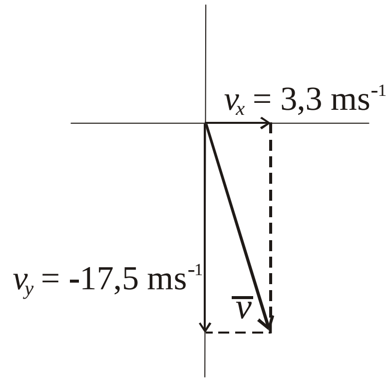
X-rigting:

$$m_1 u_{x1} + m_2 u_{x2} = (m_1 + m_2) v_x$$
$$0 + (0{,}8)(12) = (0{,}8 + 2{,}1) v_x$$
$$\therefore \quad v_x = 3{,}3 \text{ ms}^{-1}$$

Y-rigting:

$$m_1 u_{y1} + m_2 u_{y2} = (m_1 + m_2) v_y$$
$$(2{,}1)(-24{,}2) + 0 = (2{,}9) v_y$$
$$\therefore \quad v_y = -17{,}5 \text{ ms}^{-1}$$

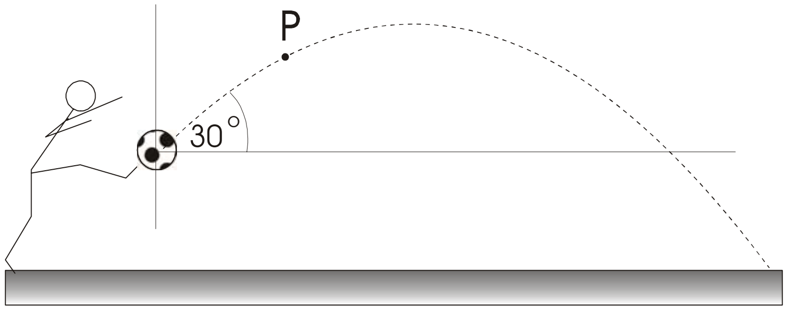
Nou dat ons die twee komponente van die snelheid het, kan ons die grootte van die oombliklike snelheid nadat die arend die duif gegryp het, bereken. Dit is die spoed wat in die vraag bereken moet word.



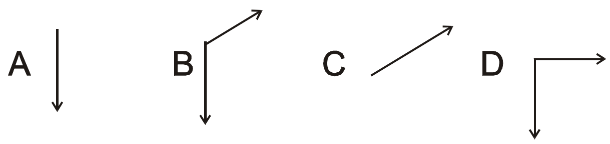
$$|\overline{v}| = \sqrt{(3{,}3)^2 + (-17{,}5)^2} = 17{,}8 \text{ ms}^{-1}$$

PROBLEEM 6: PROJEKTIEL BEWEGING (2D)

‘n Seun skop ‘n sokkerbal en die bal verlaat die seun se skoen op ‘n hoogte van 0,80 m bokant die grond met ‘n spoed van 8,8 ms^{-1} teen ‘n hoek van 30° met die horisontaal. Ignoreer lugwrywing.



6.1 Watter diagram toon die rigting(s) aan van die krag(te) wat op die bal inwerk, wanneer die bal by punt P op sy trajek is,?



Antwoord: **A** Gravitasie is die enigste krag wat op die bal inwerk terwyl dit deur die lug trek. Daar is geen horisontale kragte wat op die bal inwerk nie. Sodra die bal die seun se skoen verlaat, bestaan daar nie meer 'n krag wat die skoen op die bal uitoefen nie. Iemand wat B as antwoord kies, verwar waarskynlik momentum en krag. Dit is waar dat die bal momentum het in die rigting van beweging, maar mens mag nie momentum en krag op dieselfde vektor diagram aandui nie.

Analiseer die probleem:

X-komponente	**Y-komponente**
$a_x = 0$ $v_x = v_{xi}$ (bly konstant) By maks. hoogte: $v_x = v_{xi}$ verplasing $x = v_{xi} \times t$	$a_y = -9{,}8\ \text{ms}^{-2}$ v_y nie konstant By maks. hoogte $v_y = 0$ verplasing: $y = v_{yi}\, t + ½\, gt^2$

6.2 Skryf die *x*- en *y*-komponente van die beginsnelheid neer.

$$v_{xi} = 8{,}8\cos 60°\ \text{ms}^{-1} = 4{,}4\ \text{ms}^{-1}$$
$$v_{yi} = 8{,}8\sin 60°\ \text{ms}^{-1} = 7{,}6\ \text{ms}^{-1}$$

6.3 Bereken die maksimum hoogte bokant die grond wat die bal bereik.

Vir hierdie vraag kyk ons na die vertikale beweging (y-komponente). Wanneer die bal sy maksimum hoogte bereik is $v_y = 0$.

$$v_y = v_{yi} + gt$$
$$\therefore 0 = 7{,}6 - 9{,}8t$$
$$\therefore t = 0{,}775 = 0{,}78\,\text{s}$$

$$y = v_{yi}t + \tfrac{1}{2}gt^2$$
$$\therefore y = (7{,}6)(0{,}78) + \tfrac{1}{2}(-9{,}8)(0{,}78)^2$$
$$\therefore y = 2{,}9\,\text{m}$$

Die hoogte bo die grond = 2,9 m + 0,8 m = 3,7 m

6.4 Bereken hoe ver die seun die bal skop; dit is, hoe ver van die seun se voet af val die bal op die grond?

$$y = v_{yi}t + \tfrac{1}{2}a_y t^2$$
$$-0{,}8 = 7{,}6t - \tfrac{1}{2}(9{,}8)t^2$$

Los op vir t: $t = 1{,}65\,\text{s}$

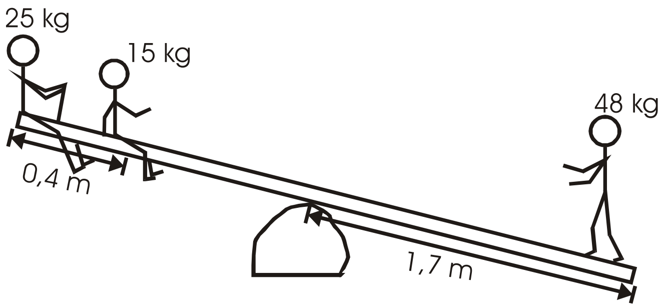
Vervang in x:

$$x = v_x t$$
$$\therefore\ x = (4{,}4)(1{,}65) = 7{,}3\,\text{m}$$

Wanneer die bal op die grond val is *y* = -0,80 m. (Dit is 0,8 m onder die punt waar die bal geskop is.) Hierdie vraag vra dat ons x bepaal as y = -0,8 m. Bereken eers die tyd wat dit die bal neem om die grond te bereik.

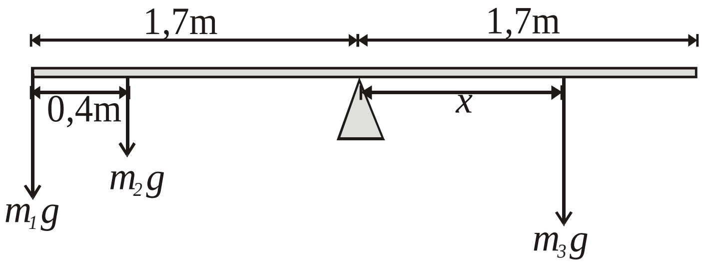
PROBLEEM 7: MOMENT VAN KRAGTE

Drie kinders speel op a wipplank wat hulle gemaak het deur 'n lang (3,4 m) homogene, uniforme plank op 'n klip in die middel te balanseer. Die twee kleinste kinders (met massas m_1 = 25 kg en m_2 = 15 kg) sit op die linkerkant (0,40 m uitmekaar) soos aangetoon in die diagram. As die oudste kind (massa m_3 = 48 kg) op die regtekantste punt staan, raak daardie punt aan die grond. Hoe ver moet die oudste kind na die klip toe loop sodat die plank weer horisontaal sal balanseer?



Onthou: Moment van 'n krag: $\tau = F \times l$, waar F die toegepaste krag is en l die afstand van die punt waar die krag toegepas word tot by die steunpunt (draaipunt).

Teken eers 'n kragtediagram:



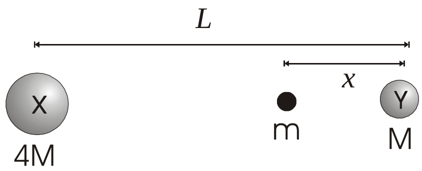
Ons pas die volgende beginsel toe: die som van regsom momente = die som van linksom momente.

(Ons neem nie die massa van die plank en die effek van gravitasie op die plank self in ag nie, omdat die plank homogeen is en in die middel op 'n klip gebalanseer is. Gravitasie het dus nie 'n draaieffek op die plank self nie.)

$$m_3 g x = m_1 g(1{,}7) + m_2 g(1{,}3)$$
$$(\div g)$$
$$(48)x = (25)(1{,}7) + (15)(1{,}3)$$
$$\therefore \quad x = 1{,}3\,\text{m}$$
$\therefore$ afstand wat oudste kind moet loop = 0,4 m

PROBLEEM 8: GRAVITASIE

Die afstand tussen die middelpunte van twee sfere is, X and Y, is L. die massa van X is 4 keer die van Y. Waar, gemeet vanaf Y, is die gravitasie krag op 'n voorwerp tussen die twee sfere, gelyk aan nul?



A. $\frac{1}{2}L$ B. $\frac{1}{3}L$ C. $\frac{1}{4}L$ D. $\frac{1}{8}L$

Antwoord: **B**

Beskou die diagram: Laat die massa van Y gelyk wees aan M, dan is die massa van X = 4M. Die massa van die ander voorwerp is m. Ons wil hê die krag van X op m (F_{Xm}) moet gelyk wees aan die krag van Y op m (F_{Ym}).

$$F_{\text{Xm}} = F_{\text{Ym}}$$

$$\frac{G(4M)m}{(L-x)^2} = \frac{GMm}{x^2}$$

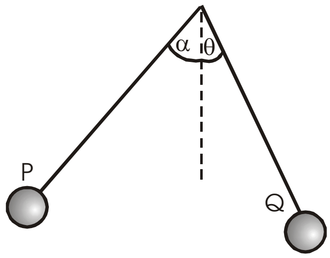
$$4x^2 = (L-x)^2$$

$$x = \tfrac{1}{3}L$$

ELEKTRISITEIT EN MAGNETISME

VEELVULDIGE KEUSEVRAE

1. Die diagram toon 'n opstelling waar twee sfere (P and Q), wat aan twee dun toutjies hang, albei positief gelaai is. Die twee hoeke wat die toutjies met die vertikaal maak is nie gelyk nie . 'n Moontlike rede hiervoor is dat



A. die krag wat Q uitoefen op P is groter as die krag wat P uitoefen op Q.
B. die lading op Q is meer as die lading op P.
C. Q is swaarder as P
D. nie een van bogenoemde nie

Antwoord: **C** Volgens Newton se derde wet, is die grootte van die krag wat Q uitoefen op P gelyk aan die grootte van die krag wat P op Q uitoefen. Dus is A en B verkeerd omdat beide Newton se derde wet weerspreek. Die enigste rede waarom die elektrostatiese afstoting tussen die twee sfere (soos bereken deur coulomb se wet) nie Q so hoog kan oplig nie soos P nie, is omdat Q swaarder is as P.

2. In watter eenheid word die arbeid verrig op een coulomb lading, terwyl dit van een punt na 'n ander in die stroombaan beweeg, gemeet?

A. Ampere
B. Volt
C. Ohm
D. Watt

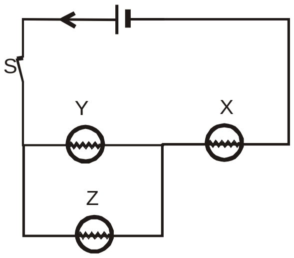
Antwoord: **B,** $V = \frac{W}{q}$ (volt = joule/coulomb)

3. Watter energie omskakeling vind hoofsaaklik plaas terwyl gelaaide deeltjies deur 'n sel met lae interne weerstand beweeg?

A. chemiese energie na elektriese potensiële energie
B. chemiese energie na kinetiese energie
C. kinetiese energie na elektriese potensisiële energie
D. warmte na kinetiese energie?

Antwoord: **A**

4. As al die gloeilampies in die stroombaan identies is en die weerstand van die geleiers en die sel weglaatbaar is, hoe vergelyk die helderheid van gloeilamp X met die van Y?



A. X is helderder as Y
B. dieselfde
C. X is dowwer as Y

Antwoord: **A**. Y en Z sal baie dowwer gloei as X.

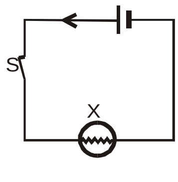
Laat ons aanvaar dat op die oomblik wat ons die helderheid van die gloeilampe vergelyk, die weerstande van die drie lampies gelyk is (sien nota hieronder). Veronderstel $R = 2\ \Omega$ vir al die gloeilamies. As die stroom deur X gelyk is aan 1 A, dan is die stroom deur Y gelyk aan 0,5 A. Die drywing in elke gloeilamp is die tempo waarteen elektriese potensiële energie omgeskakel word na lig en hitte en kan 'n aanduiding wees van die helderheid van die gloeilamp:

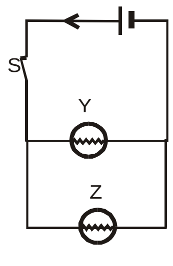
$$P_X = I^2R = (1)^2(2) = 2\,\text{W}$$

$$P_Y = (0{,}5)^2(2) = 0{,}5\text{W}$$

(Nota: Omdat X helderder gloei as Y en Z, is die temperatuur van X hoër as dié van Y en Z. As gevolg van die feit dat temperatuur die weerstand van 'n draad beïnvloed, sal die weerstand vandie drie lampies waarskynlik nie dieselfde wees soos wat mens verwag van identiese gloeilampies nie.)

5. As al die komponente in hierdie stroombane identies is en die weerstand van die geleiers en die sel weglaatbaar is, hoe vergelyk die helderheid waarmee gloeilamp X gloei met dié van gloeilamp Y?



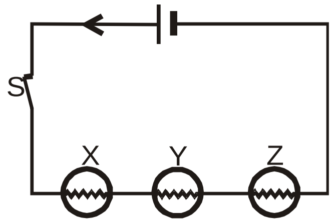


A. X is helderder as Y
B. dieselfde
C. X is dowwer as Y

Antwoord: **B,** die potesiaalverskil oor die twee gloeilampies is dieselfde en hulle eht dieselfde weestand. Die drywing $P = \frac{V^2}{R}$ in albei is dieselfde.

Let wel: Die weerstand van filament gloeilampe word beïnvloed deur die temperatuur van die filament. As die linkerkantste stroombaan gesluit word voor die ander een, kan dit gebeur dat die een lampie warmer word en dan nie meer dieselfde weerstand as die ander sal hê nie. Vir die geval hierbo aanvaar ons dat die weerstande van die gloeilampies dieselfde is op die tydstip wat hulle helderheid vergelyk word.

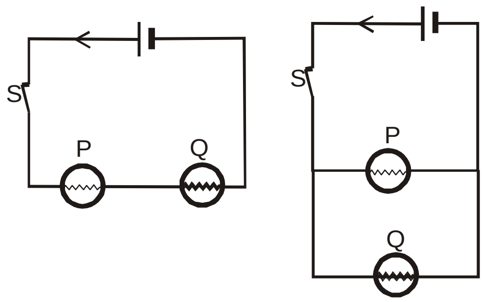
6. Die diagram toon 'n elektriese stroombaan met drie verskillende gloeilampies X, Y en Z. Met skakelaar S gesluit, sien ons dat X en Y albei gloei, maar Z gloei nie. Die rede hiervoor is dat.....



A. Z geblaas het.
B. die weerstand van Z te laag is.
C. die weerstand van Z te hoog is.
D. die stroom te laag is teen die tyd wat dit Z bereik.

Antwoord: **B**. As Z geblaas het, is die stroombaan onderbreek en sal nie een vandie lampies gloei nie. 'n Gloeilamp gloei omdat die filament warm word en dit gebeur wanneer die weerstand van 'n filament hoog is. As die weerstand laag is, sal die filament nie warm word nie en die gloeilamp sal nie gloei nie.

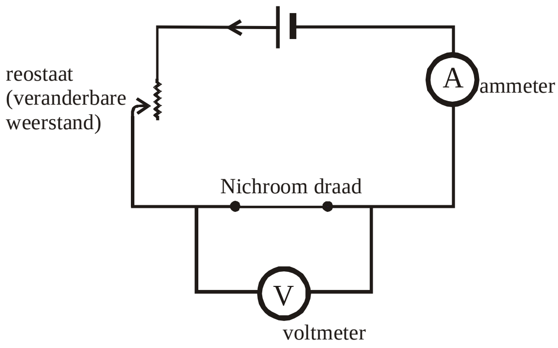
7. Twee gloeilampe, een met 'n dun filament (P) en die ander met 'n dikker filament (Q), maar met dieselfde lengte en materiaal as P, word agtereenvolgens in stroombane geskakel soos aangetoon. Die selle is identies met weglaatbare weerstand. Vergelyk die helderheid van P met dié van Q in elke stroombaan. Kies 'n kombinasie in die tabel hieronder.



	Seriestroombaan	**Parallelle stroombaan**
A	P is dowwer as Q	P is dowwer as Q
B	P is dowwer as Q	P is helderder than Q
C	P is helderder than Q	P is dowwer as Q
D	P is helderder than Q	P is helderder than Q

Antwoord: **C.** P het 'n hoër weerstand as Q. In die seriestroombaan is die stroom dieselfde deur albei gloeilampies. Beskou $P = I^2 R$; ons sien dat die gloeilamp met die hoogste weerstand die hoogste drywing het en dus die helderste gloei. In die parallelle stroombaan is die potensiaalverskil oor die lampies dieselfde en uit $P = \frac{V^2}{R}$ sien ons dat die hoogste weerstand die laagste drywing het en sal daarom dowwer gloei.

8. Susan lees in haar wetenskap boek, dat vir 'n sekere soort weerstand, die verhouding van die potensiaalverskil (V) oor die weerstand tot die stroom (I) deur die weerstand konstant is, solank die temperatuur van die weerstand konstant bly. Sy wil kyk of dit waar is vir 'n stukkie nichroomdraad, deur dit in 'n stroombaan soos in die diagram te skakel. As sy die ondersoek korrek doen, As sy die ondersoek reg doen, watter een van die tabelle hieronder kan 'n weergawe van haar resultate wees?



A

V (volt)	I (ampere)
1,0	0,2
1,0	0,2
1,0	0,2
1,0	0,2
1,0	0,2

B

V (volt)	I (ampere)
0,50	0,10
0,95	0,19
1,45	0,28
1,70	0,35
1,90	0,38

C

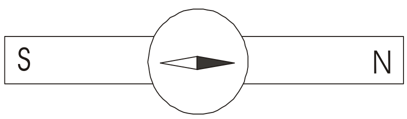
V (volt)	I (ampere)
1,1	0,20
1,0	0,19
0,9	0,21
0,9	0.20
1,0	0,21

D

V (volt)	I (ampere)
1,0	0,2
1,0	0,3
1,0	0,4
1,0	0,5
1,0	0,6

Antwoord: **B**

9. Ons plaas 'n kompas reg bo-op 'n staafmagneet en merk op dat die kompasnaald homself orienteer soos in die skets.



Ons neem dan die kompas weg van die staafmagneet en laat die kompasnaald homself orienteer in die aarde se magneetveld. In watter rigting sal die swart punt van die kompasnaald wys?

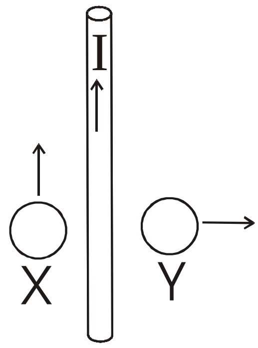
A. na noord

B. na suid

C. Dit hang af of ons indie noordelike of suidelike halfrond is.

Antwoord: **B**. Die magnetiese pool in die aarde se Suidelike halfrond (naby die geografiese suidpool) is eintlik die noordpool van die aarde se magnetiee dipool.

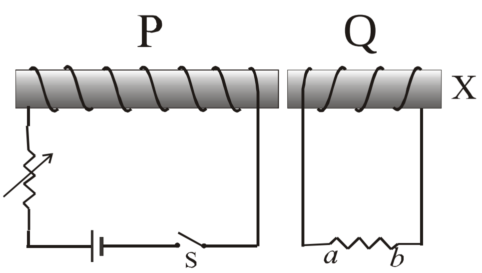
10. Die diagram toon 'n gedeelte van 'n lang reguit geleier wat stroom dra na die bokant van die bladsy. Twee metaalringe (X en Y) weerskante van die geleier word beweeg in die rigtings waarin die pyltjies wys. Die stroom wat telkens in elk van die ringe geïnduseer word, word beskryf deur:



A. X: Geen stroom geïnduseer, Y: kloksgewys
B. X: kloksgewys, Y: antikloksgewys
C. X: antikloksgewys, Y: kloksgewys
D. X:Geen stroom geïnduseer, Y: antikloksgewys
E. X: antikloksgewys, Y: Geen stroom geïnduseer

Antwoord: **A.** Op 'n konstante afstand vandie draad af, is die magneetveld van die draad konstant. Daar is dus geen verandering in magnetiese vloed deur ring X as dit parallel aan die draad beweeg nie en geen stroom word geïnduseer nie. As ring Y weg van die draad af beweeg, neem die aantal veldlyne af wat in die bladsy in deur Y gaan. Volgens Lenz se wet sal die stroom wat geïnduseer word kloksgewys wees sodat die veldlyne wat in die ring ingaan, toeneem.

11. Twee spoele word met geïsoleerde draad om twee kartonbuise gedraai en in stroombane verbind soos in die skets. 'n Student eksperimenteer hiermee deur telkens iets aan die opstelling te verander om verskillende situasies te skep. Sy gebruik 'n kompas om vas te stel wat die geïnduseerde pool by X is in elke situasie.



Situasie (i): Spoel P word na links beweeg terwyl skakelaar S gesluit is.
Situasie (ii): Deur middel van die reostaat word ide weerstand in stroombaan P geleidelik verhoog.

Besluit in elke situasie wat die geïnduseerde magnetiese pool by X sal wees.

	Situasie (i)	Situasie (ii)
A	Noord	Noord
B	Suid	Suid
C	Noord	Suid
D	Suid	Noord

Antwoord: **A**

12. Magnete trek .... aan.
 A. yster, kobalt en nikkel
 B. alle metale behalwe aluminium
 C. alle metale
 D. net staal

Antwoord: **A**

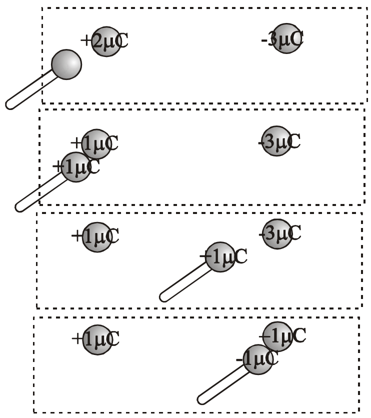
PROBLEEM 1: COULOMB SE WET

Twee klein geleidende sfere (A en B) word gelaai met +2,0 μC en -3,0 μC onderskeidelik en op 'n afstand van 5,0 cm uitmekaar geplaas. Hulle ervaar 'n elektrostatiese aantrekkingskrag F. Nou word 'n derde ongelaaide, geleidende sfeer met 'n geïsoleerde handvatsel in kontak gebring met sfeer A en dan, sonder dat dit weer aan enigiets anders raak, in kontak gebring met B. Watter afstand moet A en B nou uitmekaar geplaas word sodat hulle dieselfde aantrekkingskrag sal ervaar as aan die begin, naamlik F?

Bepaal eers die aanvanlike aantrekking F, tussen die sfere.

$$F = \frac{kq_1q_2}{r^2}$$
$$F = \frac{(9 \times 10^9)(2 \times 10^{-6})(3 \times 10^{-6})}{(0{,}05)^2}$$
$$F = 21{,}6\,\text{N}$$

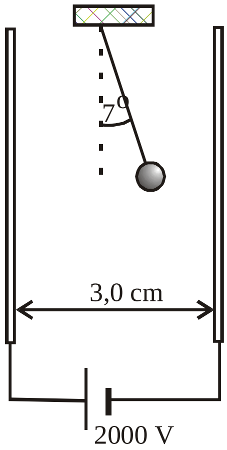
Bepaal nou wat die uiteindelike lading op die sfere sal wees nadat dit met die derde sfeer in kontak was. Sien die diagram.



Ons sien datdie finale lading op die twee sfere +1,0 μC en -1,0 μC is. Die aantrekkingskrag tussen hulle moet 21,6 N sos vereis deur die vraag.

$$21{,}6 = \frac{(9 \times 10^9)(10^{-6})(10^{-6})}{r^2}$$
$$\therefore\ r = 0{,}0204\ \text{m}$$
$$\therefore\ r = 2{,}0\,\text{cm}$$

PROBLEEM 2: 'N GELAAIDE DEELTJIE IN 'N UNIFORME VELD.



'n Klein, gelaaide sfeer word gehang aan 'n baie ligte toutjie tussen twee teenoorgesteld gelaaide plate, soos aangetoon in die diagram. Die afstand tussen die plate is 3,0 cm en die potensiaalverskil tussen die plate is 2000 V. Die massa van die sfeer is 8,0 g en die hoek tussen die toutjie en die vertikaal is 7,0°.

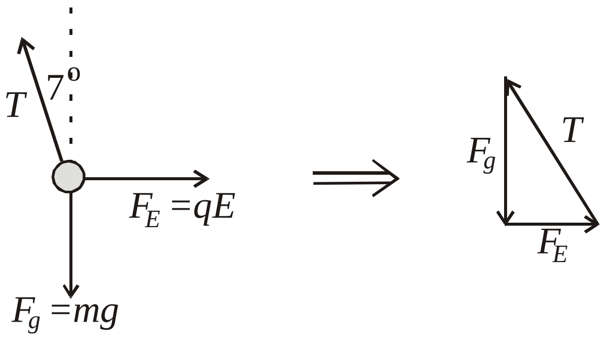
2.1 Bereken die grootte van die elektriese veld tussen die plate.

$$E = \frac{V}{d}$$

$$\therefore\ E = \frac{2000}{0{,}03} = 6{,}67 \times 10^4\ \text{Vm}^{-1}$$

2.2 Bereken die lading op die sfeer. Gee die antwoord in nC.

Die kragte wat op die sfeer inwerk is in ewewig.

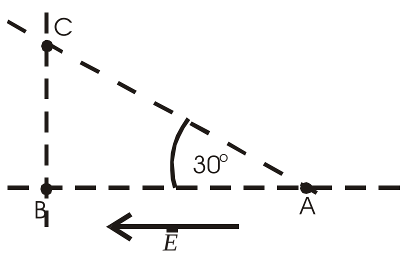


$$F_E = F_g \tan 7°$$
$$= (0{,}008)(9{,}8)\tan 7°$$
$$= 9{,}63 \times 10^{-3}\ \text{N}$$

$$\therefore qE = 9{,}63 \times 10^{-3}\ \text{N}$$
$$\therefore q = 1{,}44 \times 10^{-7}\ \text{C} = 144\ \text{nC}$$

PROBLEEM 3: WERK EN ENERGIE IN 'N ELEKTRIESE VELD

'n Deeltjie met massa $3{,}00 \times 10^{-23}$ kg en lading + 1,50 nC beweeg in 'n uniforme elektriese uit rus van punt A af tot verby punt B waar die spoed $2{,}00 \times 10^6$ ms^{-1}. Die afstand tussen punt A en punt B is 5,00 cm.



3.1 Hoeveel werk word deur die veld op die deeltjie verrig?

$$W = \Delta E_k = E_{kB} - E_{kA}$$
$$= \tfrac{1}{2} m v_B^2 - 0$$
$$= \tfrac{1}{2}(3 \times 10^{-23})(2 \times 10^6)^2$$
$$= 6{,}0 \times 10^{-11}\ \text{J}$$

3.2 Bepaal die potensiaalverskil tussen punte A en B en verduidelik wat die antwoord beteken in terme van die definisie van potensiaalverskil.

$$V_{AB} = \frac{W_{A \to B}}{q} = \frac{6 \times 10^{-11}}{1{,}5 \times 10^{-9}} = 0{,}04\ \text{V}$$

Dit beteken dat 0,04 joule werk verrig is (deur die veld) per eenheidslading om die gelaaide deeltjie van punt A na punt B te beweeg.

3.3 Bereken die grootte van die elektriese veld.

$$E = \frac{V}{d} = \frac{0{,}04}{0{,}05} = 0{,}8\ \text{Vm}^{-1}$$

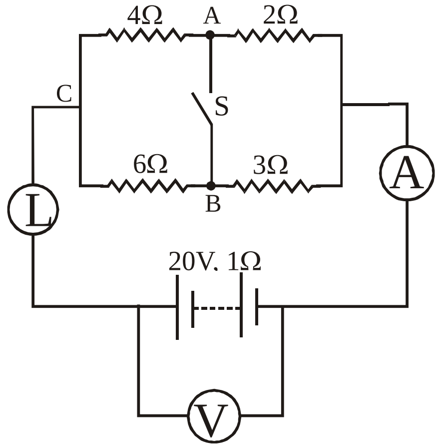
3.4 'n Identiese deeltjie word deur 'n ekterne krag beweeg van punt C na punt A. Hoeveel arbeid word deur hierdie krag verrig? Verduidelik jou antwoord.

$$W = 6{,}0 \times 10^{-11}\ \text{J}$$

Omdat die veld uniform is, is punt B en punt C by dieselfde elektriese potensiaal. Dit beteken dat 'n gegewe gelaaide deeltjie dieselfde elektriese potesiële energie by C sal hê as by B en daarom sal dieselfde hoeveelheid arbeid verrig word om die deeltjie van C na A te neem as wat die veld sal verrig om die deeltjie van A na B te neem.

PROBLEEM 4: ELEKTRIESE STROOMBAAN

'n Stroombaan word opestel soos aangetoon in die diagram. Die gloeilamp L se weerstand is 0,4Ω. Die effek wat die temperatuur het op die weerstand van die gloeilamp mag verontagsaam word.



4.1 Met skakelaar S oop, bepaal die effektiewe weerstand R_{eff}, van die stroombaan, battery ingesluit.

Vir die parallelle kombinasie: $\frac{1}{R} = \frac{1}{4+2} + \frac{1}{6+3} = \frac{5}{18}$

$$\therefore R_{parallel} = 3{,}6\,\Omega$$

$$\therefore \quad R_{eff} = 3{,}6 + 0{,}4 + 1 = 5\,\Omega$$

4.2 Bereken die lesing op die ammeter met S steeds oop.

$$I = \frac{V}{R} = \frac{20}{5} = 4\text{ A}$$

4.3 Bereken die lesing opdie voltmeter met S steeds oop.

Die lesing op die voltmeter gee die hoeveelheid energie wat beskikbaar is vir die stroombaan, per eenheidslading wat die battery verlaat. As die battery geen interne weerstand gehad het nie, sou al 20 joule energie (per eenheidslading) beskikbaar wees vir die stroombaan. As gevolg van die interne weerstand, word daar egter nou van die energie reeds in die battery na hitte omgeskakel en is dit nie beskikbaar vir die res van die stroombaan nie. Hierdie hoeveelheid word soms die "verlore volts" genoem.

Dus, die voltemeterlesing is gelyk aan die totale hoeveelheid energie wat die battery kan verskaf (per eenheidslading), dit is die emk (ε), minus die energie wat omgeskakel is na hitte voordat die ladingsdraers die battery verlaat het, dit is Ir.

$$V = \varepsilon - Ir$$

$$\therefore V = 20 - (5)(1) = 15\text{ V}$$

4.4 Met S steeds oop, bepaal die potesiaalverskil tussen punte A en B.

Die potensiaalverskil oor die parallelle kombinasie: $V = IR = (4)(3{,}6) = 14{,}4\text{ V}$

Nou kan ons die strome deur die boonste en onderste vertakkings van die parallel kombinasie bereken:

$$\therefore I_{bo} = \frac{14{,}4}{(4+2)} = 2{,}4\text{ A} \quad \text{en} \quad I_{onder} = \frac{14{,}4}{(6+3)} = 1{,}6\text{ A}$$

$$\therefore V_{CA} = I_{CA}R = (2{,}4)(4) = 9{,}6\text{ V} \quad \text{en} \quad V_{CB} = I_{CB}R = (1{,}6)(6) = 9{,}6\text{ V}$$

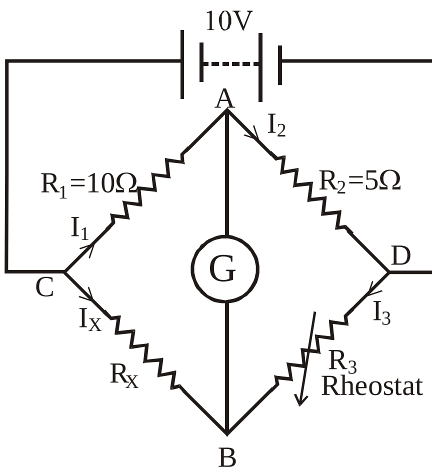
Dus, die potensiaal by A is gelyk aan die potensiaal by B en daar is geen potesiaalverskil tussen A en B nie. $V_{AB} = 0\text{ V}$.

4.5 Skakelaar S word nou gesluit. Wat sal die effek daarvan wees op die helderheid waarmee die gloeilamp brand?

Geen effek, omdat daar geen potesiaalverskil tussen A en B was nie, sal daar geen stroom vloei van A na B as die skakelar gesluit word nie en die stroom in die stroombaan sal nie beïnvloed word nie.

PROBLEEM 5: DIE WHEATSTONE BRUG

Die Wheatstone brug is 'n apparaat wat gebruik word om weerstand akkuraat te meet. Met die opstelling hieronder wil ons die weestand van R_X meet. aanvanklik sien ons dat die galvanometer 'n strrom registreer tusen A en B met die reostaat 6Ω gestel.



5.1 Hoe moet ons te werk gaan ons die weerstand van R_X te meet?

Ons moet die weerstand van die reostaat verander totdat die galvanometer geen stroom meet nie. Wanneer dit die geval is, weet ons dat $V_{AB} = 0$ of $V_A = V_B$, en daarom is $V_{CA} = V_{CB}$ en $V_{AD} = V_{BD}$. Dus is

$$I_1 R_1 = I_X R_X$$

$$\text{and} \quad I_2 R_2 = I_3 R_3$$

$$\therefore \quad \frac{I_1 R_1}{I_2 R_2} = \frac{I_X R_X}{I_3 R_3}$$

Maar as daar geen stroom tussen A en B bestaan nie, dan is $I_1 = I_2$ en $I_X = I_3$

$$\therefore \quad \frac{R_1}{R_2} = \frac{R_X}{R_3}$$

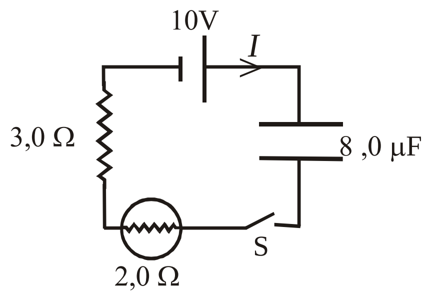
$$\therefore \quad R_X = \frac{R_1 R_3}{R_2}$$

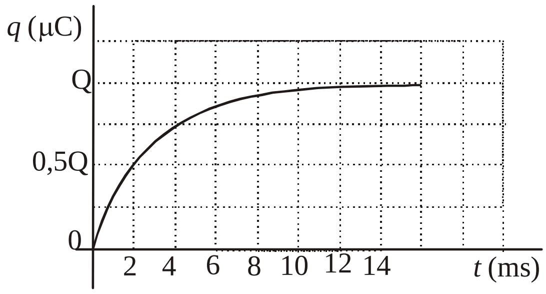
5.2 As ons die reostaat stel op 8Ω, sien ons dat die lesing op die galvanometer nul is. Bepaal die weerstand van R_X.

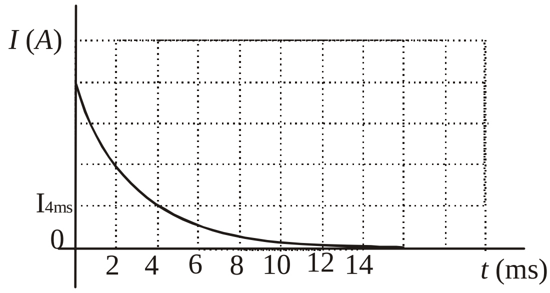
$$R_X = \frac{(10)(8)}{5} = 16\,\Omega$$

PROBLEEM 6: DIE RC-STROOMBAAN

Die kapasitor in die stroombaan, met 'n kapasitansie van 8,0 μF, sal volledig gelaai wees na 12,0 ms van die oomblik wat die skakelaar gesluit is. Die stroombaan bevat ook 'n resistor met weerstand 3,0 Ω en 'n gloeilamp van 2,0 Ω. Die interne weerstand van die sel kan geïgnoreer word. Bestudeer die grafieke en beantwoord die vrae wat volg.







6.1 Bereken die waarde van Q wat op die grafiek aan die linkerkant aangedui is.

Q is die lading op die kapasitor wanneer dit volledig gelaai is, dan is die stroom in die stroombaan nul en die potensiaalverskil oor die resistor en die gloeilampie is dus ook nul. Die potensiaalverskil oor die kapasitor sal daarom 10 V wees.

$$\therefore \quad Q = CV = (8\mu F)(10V) = 80\mu C$$

6.2 Bereken die waarde van I by 4 ms soos aangedui op die regterkantste grafiek.

Bereken eers die aanvanklike (maksimum) waarde van die stroom. By $t = 0$ s is die lading op en die potensiaalverskil oor die kapasitor nul. Die potensiaalverskil oor die twee weerstande is dus 10 V.

$$I = \frac{V}{R} = \frac{10}{5} = 2 \text{ A}$$

Die waarde van I by 4 ms is 'n kwart van die aanvanklike waarde $\therefore I_{4ms} = 0{,}5$ A.

6.3 Calculate the power in the bulb at 4 ms.

$$P = I^2 R = (0{,}5)^2 2 = 0{,}5\text{W}$$

6.4 What would be the area of the plates if the plate separation is 5 mm.

$$C = \frac{\varepsilon_0 A}{d}$$

$$8 \times 10^{-6} = \frac{(8{,}85 \times 10^{-12})(A)}{0{,}005}$$

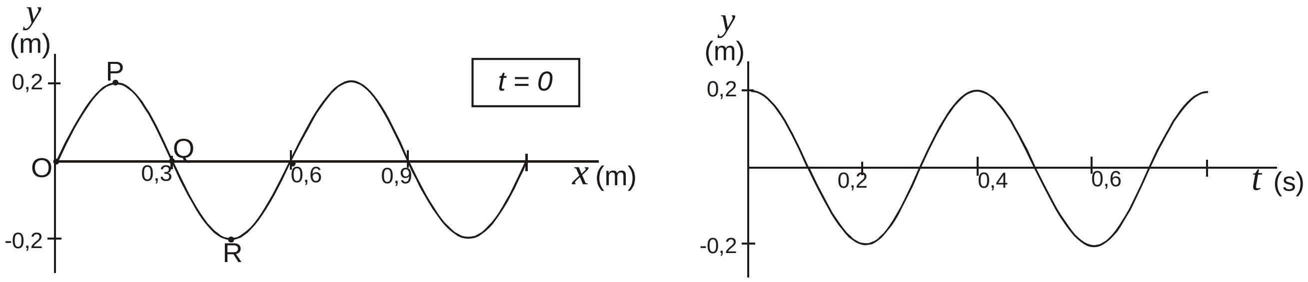
$$\therefore \quad A = 4{,}5 \times 10^3 \text{ m}^2$$

Ons sien dat dit 'n geweldige groot area is vir 'n stroombaan komponent. In werklikheid word parallelplate nie in stroombane gebrui nie, maar eerder silindriese kapasitore wat basies twee paralleplate is, gekei deur 'n isolerende materiaal en opgerol is in 'n silinder.

GOLWE, KLANK EN LIG

PROBLEEM 1: TRANSVERSALE GOLWE

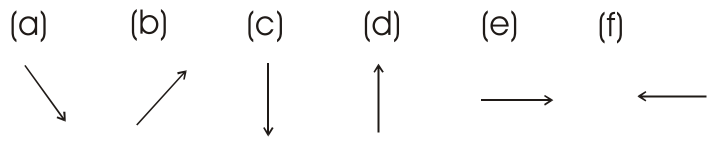
Die figuur toon twee grafieke vir een en dieselfde golfbeweging in 'n gegewe tou. Die golf beweeg na regs. Die eerste grafiek toon die vertikale verplasing van die tou as 'n funksie van die posisie van die deeltjies in die tou op tydstip t = 0. Die tweede grafiek toon die vertikale verplasing van slegs een van die deeltjies in die tou as 'n funksie van tyd.



1.1 Wat is die amplitude, golflengte, peiode, frekwensie en spoed van die golf?

Amplitude: $A = 0{,}2$ m
Golflengte: $\lambda = 0{,}6$ m (afgelees op die linkerkantste grafiek.)
Periode: $T = 0{,}4$ s (afgelees op die regterkanste grafiek)
Frekwensie: $f = 1/T = 2{,}5$ Hz
Golfspoed: $v = f\lambda = 1{,}5$ ms^{-1}

1.2 Vir elk van die punte O, P, Q en R op die linkerkanste grafiek, kies van die moontlikhede hieronder die rigting waarin daardie spesifieke punt sal beweeg net na t = 0.



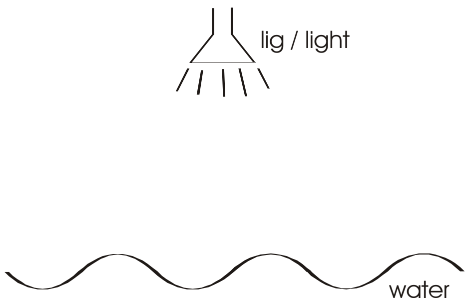
Antwoord: punt O (c); punt P (c); punt Q (d); punt R (d)
Hierdie grafiek kan gesien word as 'n foto van die tou op 'n gegewe tydstip. Elke deeltjie in die tou is besig om op en af te ossilleer terwyl die golf besig is om na regs in die tou te beweeg. Let wel: Die golf verplaas nie deeltjies van een punt na 'n ander nie in die bewegingsrigitng van die golf nie.

1.3 Van watter punt (O, P, Q of R) is die ander diagram 'n posisie - tyd grafiek? Verduidelik jou keuse.

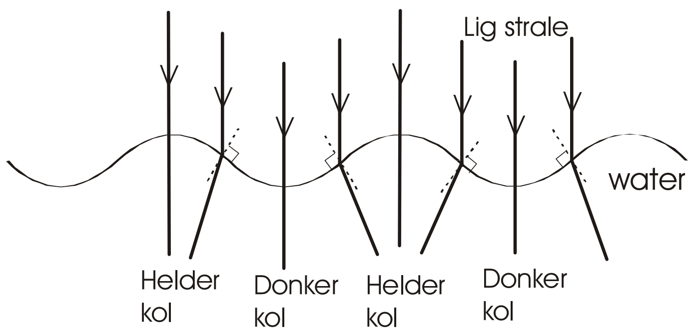
Antwoord: P
Op die tydstip waarvoor die die eerste grafiek geteken is, het punt P reeds sy maksimum posisie bereik en sal begin om afwaarts te beweeg. (Sien vraag 1.2) Dit stem ooreen met die posisie-tyd grafiek wat 'n deeltjie toon wat by die maksimum verplasing begin en daarna afwaarts beweeg.

PROBLEEM 2: GOLWE IN ‘N GOLFTENK

In ‘n golftenk word lig reg van bo af op vlak water waarin klein golfies gemaak word, geskyn. Die diagram toon ‘n sy-aansig van die golfies. Die patroon van lig en skadulyne (of sirkels) wat gevorm word op ‘n wit oppervlak onder die golftenk, is ‘n gevolg van die golfpatroon in die golftenk. Verduidelik.



Die beste manier om dit te verduidelik is om ‘n straaldiagram te teken wat die rigting van die ligstrale, na breking by die oppervlak van die water, sal aandui. Wanneer ligstrale van ‘n opties minder digte medium na ‘n opties digter medium beweeg, breek die ligstrale na die normaal toe. (Onthou: die normaal is ‘n denkbeeldige lyn wat loodreg is op die skeidingsvlak tussen twee mediums.) Wanneer ‘n ligstraal ‘n medium loodreg binnegaan sal die rigting daarvan nie verander nie.



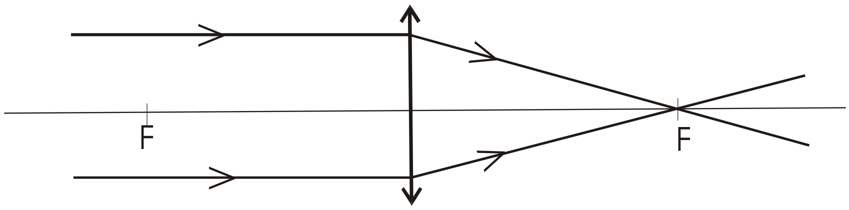
Donker of skadukolle sal vorm waar die meeste ligstrale weggebreek word van daardie spesifieke kol af. Ons sien dus dat die helder lyne vorm onder die kruine en die donker of skadulyne vorm onder die dale.

PROBLEEM 3: LENSE

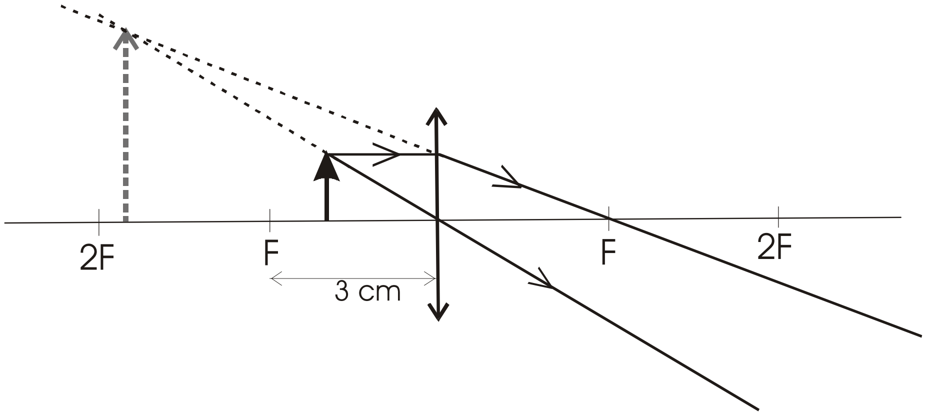
Gebruik straaldiagramme om aan te dui hoe die beeld vorm in elk van die volgende gevalle. Bebruik die simbool ↕ om ‘n konvekse lens aan te dui.

3.1 ‘n Konvekse lens met brandpuntafstand 5 cm, met ligstrale wat van ‘n bron afkom wat baie ver van die lens af is.

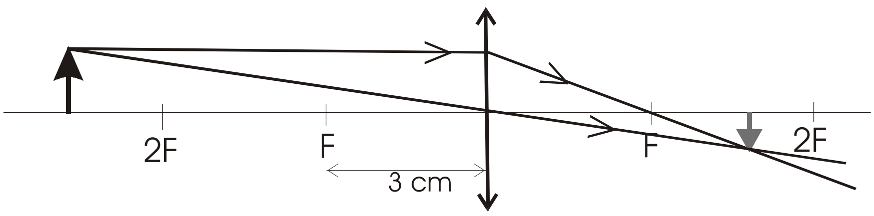
Ligstrale wat van ‘n baie ver bron afkom kan hanteer word asof hulle ewewydig aan die hoofas is.



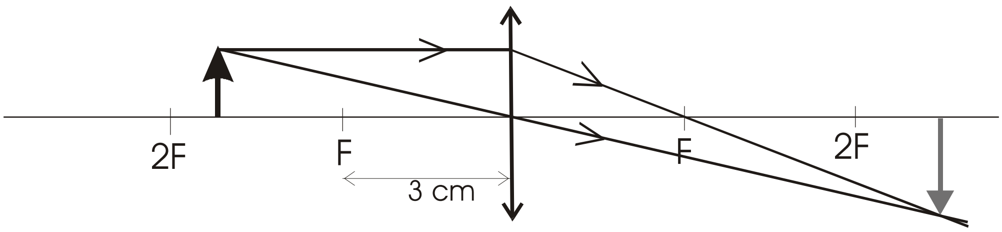
3.2 ‘n Konvekse lens met brandpuntafstand 3 cm en ‘n voorwerp 2 cm links van die lens.



3.3 ‘n Konvekse lens met brandpuntafstand 3 cm en ‘n voorwerp 8 cm links van die lens.

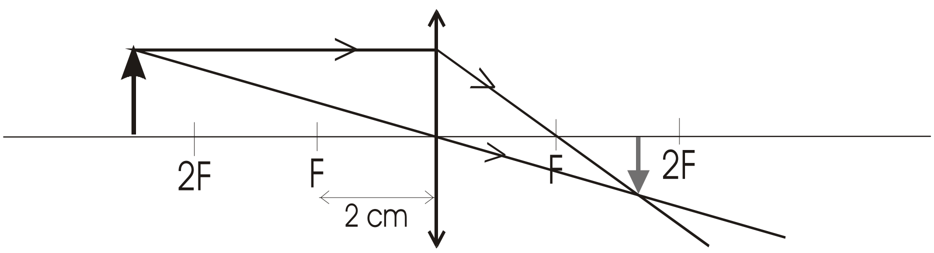


3.4 ‘n Konvekse lens met brandpuntafstand 3 cm en ‘n voorwerp 5 cm links van die lens.



3.5 ‘n Konvekse lens met brandpuntafstand 2 cm en ‘n voorwerp 5 cm links van die lens. Sê ook hoe ‘n lens met ‘n korter brandpuntafstand verskil van ‘n lens met ‘n langer brandpuntafstand.

Wanneer ‘n lens ‘n kort brandpuntafstand het is dit ronder as ‘n lens met ‘n langer brandpuntafstand.



3.6 Watter geval hierbo kom ooreen met:

(i) die gebruik van 'n vergrootglas om 'n klein voorwerp te ondersoek,

(ii) die gebruik van 'n vergrootglas om 'n gaatjie te brand in 'n droë blaar,

(iii) beeldvorming in die oog.

Verduidelik jou antwoorde.

(i) **3.2** In hierdie geval sien ons 'n regop, vergrote beeld soos wat nodig is wanneer ons 'n klein voorwerp wil ondersoek. Ons sien dus dat as ons 'n lens as 'n vergrootglas wil gebruik, die voorwerp tussen die lens en die brandpunt moet wees.

(ii) **3.1** Die son is 'n verafgeleë voorwerp en die strale van die son kan beskou word as strale wat ewewydig aan die hoofas op die lens inval. Sulke strale konvergeer in die brandpunt en die intensiteit in die brandpunt is dan hoog genoeg om iets soos 'n droë blaar te brand.

(iii) **3.3 tot 3.5** Die kornea en die lens van die oog konvergeer ligstrale wat van 'n voorwerp af kom wat verder van die oog af is as die brandpunt. Die beeld wat op die retina vorm is reëel, omgekeer en baie kleiner as die voorwerp. (Die retina is die ligsensitiewe vlies aan die agterkant van die oog waarop die beeld vorm.)

3.7 Gebruik diagramme 3.3 to 3.5 om die funksie van die lens en die lensspiere in die oog te verduidelik

Dit is nodig om daarop te let dat ons net iets duidelik kan sien as die beeld presies op die retina vorm. As die beeld agter of voor die retina vorm, sal ons 'n dowwe of uitfokus beeld waarneem. Die afstand tussen die ooglens en die retina is konstant. As die lens dus nie op een of ander manier kon aanpas by die voorwerpafstand nie, sou die beeld gewoonlik nie presies op die retina gevorm het nie.

As ons diagramme 3.3 en 3.4 vergelyk, sien ons dat hoe nader 'n voorwerp aan die lens is, hoe verder is die beeld van die lens af (met dien verstande dat die voorwerp nie nader aan die lens as die brandpunt is nie) Veronderstel 3.3 verteenwoordig 'n voorwerpafstand wat net reg is vir 'n spesifieke ooglens en dat die beeld reg op die retina vorm. As die voorwerp nader aan die oog kom, beweeg die beeld verder weg van die lens af en sal dan agter die retina vorm.

Vergelyk nou diagramme 3.4 en 3.5. Hier sien ons dat vir 'n lens met 'n korter brandpuntafstand die beeld nader aan die lens vorm. Dus, as die lens ronder kon word (en 'n gevolglik korter brandpuntafstand kon hê) as die voorwerp nader aan die oog kom, sou die beeld weer reg op die retina vorm. Dit is presies wat die lensspiere doen; as 'n voorwerp naby aan die oog is, trek die lensspiere saam en sodoende word die lens meer gerond, sodat die beeld steeds op die retina vorm.

Wanneer 'n persoon ouer word, gebeur dit dikwels dat die lensspiere hulle vermoë om saam te trek verloor, en daarom kan die lens se kromming nie genoeg toeneem vir die persoon om op naby voorwerpe te fokus nie. So 'n persoon het dan nodig om 'n bril met konvekse lense te dra om te kompenseer vir die gebrek aan ronding van die ooglense.

PROBLEEM 4: DOPPLER EFFEK

Die klankbron van 'n skip se sonar toestel funksioneer by 'n grekwensie van 30 kHz. 'n Duikboot beweeg direk weg van die skip met 'n spoed van 24 ms^{-1}. die skip is in rus in die water en stuur 'n sein uit wat teen die bewegende duikboot weerkaats. Nadat die sein by die duikboot weerkaats het, word dit weer geregistreer by die sonar toestel op die skip. Die spoed van klank in water is 1480 ms^{-1}.

4.1 Bereken die frekwensie van die klankgolf soos wat dit deur 'n toestel op ie duikboot waargeneem sal word.

$$f_L = \frac{v - v_L}{v - v_s} f_s$$

Beskou die duikbuit in dié deel van die probleem asdie "luisteraar" L en die skip as die bron S. Ons moet f_L bereken. (Onthou dat v_L en/of v_S positief is wanneer L en/of S in dieselfde rigting as die klank beweeg en negatief wanneer hulle in die teenoorgestelde rigitng as die klank beweeg.)

$$f_S = 30\,\text{kHz}$$
$$v_L = +24\,\text{ms}^{-1}$$
$$v_S = 0$$
$$f_L = ?$$

$$f_L = \left(\frac{1480 - 24}{1480}\right) 30 = 29{,}5\,\text{kHz}$$

4.2 Bereken die frekwensie wat geregistreer word deur die skip se sonar toestel nadat die weerkaatste sein by die skip aangekom het.

In hierdie deel van die probleem beskou ons die duiboot as die bron, omdat die klanksein nou van die duikboot afkom. Die frekwensie van die weerkaatste sein is nou f_S. Hier is v_S negatief, omdat die klank na die skip toe beweeg terwyl die duikboot weg van die skip af beweeg.

$f_L = ?$ (die sein wat deur die skip waargeneem word)

$f_S = 29{,}5\, kHz$ (die frekwensie wat weerkaats is by die duikboot $= f_L$ van 4.1)

$v_L = 0$

$v_S = -24\, ms^{-1}$

$$f_L = \frac{1480}{1480 + 24} 29{,}5 = 29{,}0\,\text{kHz}$$

Deur die frekwensies van die uitgaande sein en weerkaatste sein te vergelyk, kan die skip vasstel wat die spoed van 'n vaartuig in sy omgewing is.