



Province of the
EASTERN CAPE
EDUCATION

Iphondo leMpuma Kapa: Isebe leMfundo
Provinsie van die Oos Kaap: Departement van Onderwys
Porafensie Ya Kapa Botjhabela: Lefapha la Thuto

NATIONAL SENIOR CERTIFICATE

KEREITI 12

LOETSE 2026

FISIKALE SAENSESE P1

MATSHWAO: 150

NAKO: 3 dihora

Pampiri ena ya dipotso e na le maqephe a 20 ho kenyelletsa le didatha shithi tse 3.

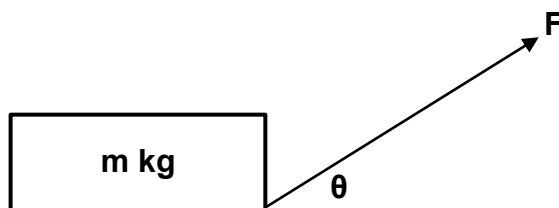
DITAELO LE TLHAHISOLESEDING

1. Ngola LEBITSO le FANE ya hao ka botlalo dibakeng tse nepahetseng BUKENG YA HO ARABELA.
2. Pampiri potso ena e na le dipotso tse leshome(10). Araba dipotso KAOFELA.
3. Qala potso ka NNGWE leqepheng le LETJHA.
4. Nomora dikarabo ka ho nepahetseng ho latela sisetemo e sebedisitsweng ho pampiri ya dipotso ena.
5. Siya MOLA O LE MONG dipakeng tsa dipotswana mohl dipakeng tsa POTSO 2.1 le POTSO 2.2.
6. O ka sebedisa khaltjhuleitha e sa porokeremuwang.
7. O ka sebedisa matematikale instrumente e nepahetseng.
8. Difomula le disabstitjhushene di tlameha ho bontshwa dikhaletjhuleisheneng TSOHLE.
9. Atametsa di-numerical answer ho bonnyane didesimale tse PEDI qetellong.
10. Fana ka tshehetso, dimanollo, jwalo jwalo moo ho hlokehang.
11. O eletswa ho sebedisa DATHA SHITI e hokahantsweng.
12. Ngola ka makgethe le ka mongolo o balehang.

POTSO YA 1: DIPOTSO TSA KGETHO

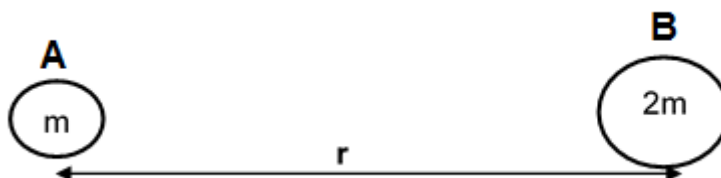
Ho fanwe ka dikgetho tse fapaneng e le dikarabo tse ka nepahalang dipotsong tse latelang. Potso ka nngwe e na le karabo e le NNGWE feela e nepahetseng. Kgetha karabo o be o ngole tlhaku feela (A–D) pela dinomoro tsa dipotso (1.1 ho ya ho 1.10) BUKENG YA HO ARABELA, mohlala 1.11 B.

- 1.1 Constant force F e apolauwa bolokong ya mass, m ho angle θ ho horozonthale empa boloko ha e ya ka ya tsamaya. Khoefishiente ya static frictional force dipakeng tsa boloko le safeise ke μ_s . Makenenetjhute ya static frictional force e lekana le:



- A F
 B $F \cos \theta$
 C $\mu_s(mg - F \cos \theta)$
 D $\mu_s(mg - F \sin \theta)$ (2)

- 1.2 Di-isolated body tse pedi, **A** le **B**, di na le di-mass m le $2m$ ka tatellano, di beuwe distense ya r ho tloha ho e nngwe.

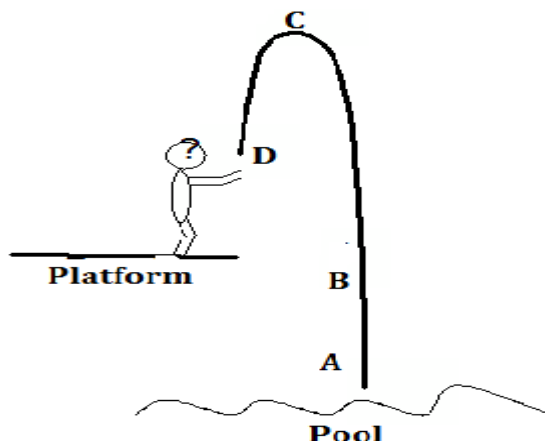


Shebisisa ditatemente tse latelang mabapi le gravitational force e ekesethuweng ke di-body e nngwe ho e nngwe.

- (i) Force e ekesethuweng ke body **B** ho body **A** ke hafo e ekesethuweng ke body **A** ho body **B**.
 (ii) Force e ekesethuweng ho di-body ha e a ikamahanya le di-mass tsa di-body.
 (iii) Force e ekesethuweng ho body **A** ke body **B** e lekana empa e ophosithi ho e ekesethuweng ho body **B** ke body **A**.
 (iv) Diforce di tla dula di le athrakhthive.

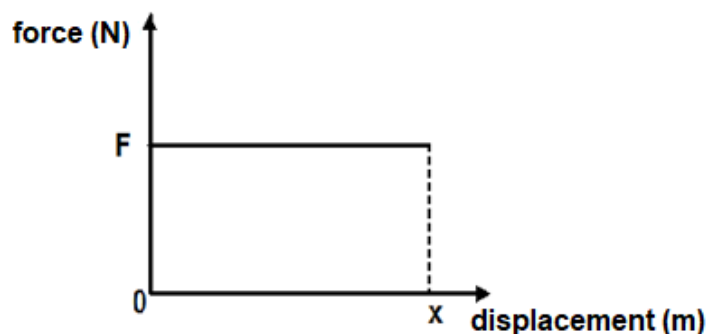
- A (i), (ii) le (iv) feela.
 B (iii) le (iv) feela.
 C (ii), (iii), le (iv) feela.
 D (iv) feela. (2)

- 1.3 Moshemane ya emeng ho platform o akgela lejwe hodimo ho ya ka phuling e ka tlase ho platform. Ke ho diposishene **A**, **B**, **C** le **D** kapa **E LE NNGWE** moo magnitude ya Momentum ya lejwe e tla ba maximum?



- A Posishene **A**
 B Posishene **B**
 C Posishene **C**
 D Posishene **D** (2)

- 1.4 Kerafo e ka tlase e emetse constant force **F** e ekethang ho objekthe ho dispoisemente **X**. Force le dispoisemente di dayerekesheneng e tshwanang.



Ke sefe se le SENG ho ditatemente tse latelang se ka fihlellwang o ipapisitse le kerafo?

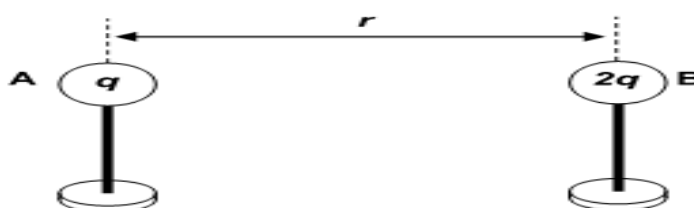
- A Gradiante ya kerafo e emetse work done e entsweng ke force.
 B Gradiante ya kerafo e emetse change in kinetic energy ya objekethe.
 C Area e ka tlasa kerafo e emetse work done e entsweng ke force.
 D Area e ka tlasa kerafo e emetse phawa e dissipheithuweng ke force. (2)

- 1.5 Net force F e akselereitha isolated objekethe tse pedi, X le Y tse neng di eme ho setereiti laene ka nako t ka ho bontshitsweng ka tlase. Objekethe X e ekseperinsiensa akeselereishene ya a le objekethe Y akeselereishene ya $2a$. Mass ya objekethe X e HABEDI ho na le ya objekethe Y .



Haeba amaonte ya work done e entsweng ke F ho Objekethe X ke W , jwale amaonte ya work done e entsweng ke force F ho Objekethe Y ke:

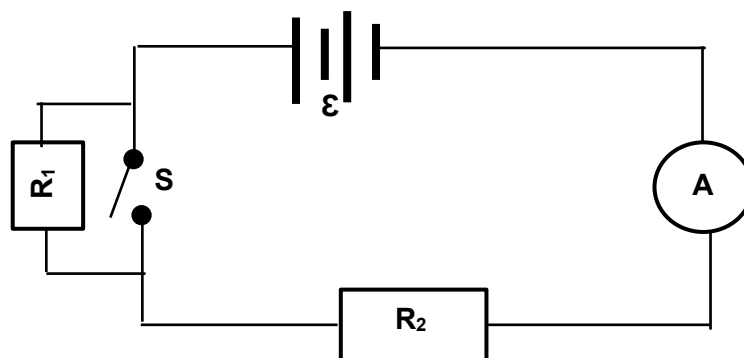
- A $\frac{1}{2} W$
 B W
 C $4 W$
 D $2 W$ (2)
- 1.6 Momamedi o tsamaya ka constant velocity ho tla ho stationary source ya modumo. Frequency ya modumo e utluwang ke momamedi e hodimo ho na le frequency e emithuweng ke source, hobane ...
- A wavelength e obsevueng ke momamedi e ba telele.
 B di-wave front tse ngata di fihlella momamedi motsotswana ka mong.
 C di-wave front tse mmalwa di fihlella momamedi motsotswana ka mong.
 D wavelength e obsevueng ke momamedi e ba kgutshwane. (2)
- 1.7 Sketjh dayakeramo e ka tlase e bontsa di-metal sphere tse nyane tse pedi, A le B , tse ho di-insulated stand di na le ditjhatjhe tse nang le magnitude q le $2q$ ka tatellano. Distance dipakeng tsa di-centre tsa di-sphere tse pedi ke r .



Di-sphere di eksetha force ya magnitude F ho se seng. E ka kang makenetjute ya force eo di-sphere di e ekesethang se seng ho se seng haeba distance dipakeng tsa tsona ke $\frac{1}{2}r$?

- A F
 B $4 F$
 C $\frac{1}{2} F$
 D $2 F$ (2)

- 1.8 Battery ya emf $\mathcal{E}$ le internal resistance e sa natswang e hokahantswe ho sekethe, jwalo ka ha ho bontshitswe dayekeramong e ka tlase. Reseistense ya R_1 le R_2 di hodimo.



Ke efe e le NNGWE kopanyo ho tse latelang mabapi le di-ammeter reading e tla NEPAHALA ha switjhi **S** e butswe le ha switjhi **S** e kwetswe?

	SWITJHI E BUTSWE	SWITJHI E KWETSWE
A	Amitha e bala current ho R_1 feela	Amitha e bala current ho R_2 feela
B	Amitha e bala current ho R_2 feela	Amitha e bala current ho R_1 le R_2 ka bobedi
C	Amitha e bala current ho R_1 le R_2 ka bobedi	Amitha e bala current ho R_1 le R_2 ka bobedi
D	Amitha e bala current ho R_1 le R_2 ka bobedi	Amitha e bala current ho R_2 feela

(2)

- 1.9 Ke efe e le NNGWE ho diphetoho tse latelang ho design ya AC jenereitha e tla nyolla makesimamo emf?

- A Atisa lenane la di-turn ho khoyele
- B Sebedisa di-brush tse kgolo.
- C Tjhenthja pholarithi ya dimakenete.
- D Sebedisa di-slip ring tse kgolo.

(2)

- 1.10 Ha **GREEN** laete e insidenthuwa ho cathode ya photo-electric sele le amitha e hokahantswe seketheng e rejistaresha kharente. Green laete jwale e repoleiswa ka **BLUE** laete e nang le inthensithi e tlase le insidente ho photo-electric sele e le nngwe.

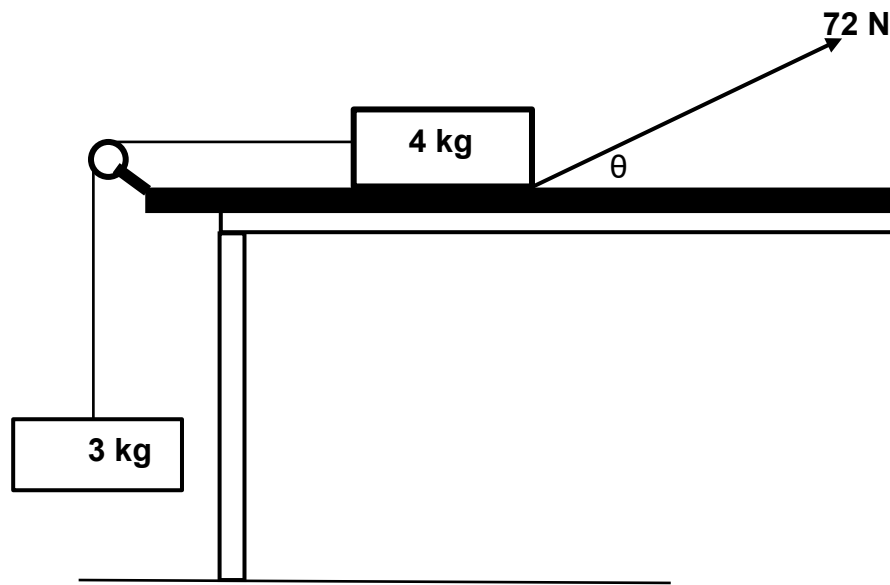
E ka bapiswa jwang nomoro ya di-photo-electric eleketerone tse emithuweng ka motsotswana ka mong le sepiti sa di-photo-electron ya **BLUE** laete e bapiswa le ya **GREEN** laete?

	AMAONTE YA DI-PHOTOELECTRON MOTSOTSWANA KA MONG	SEPITI SA DI- PHOTOELECTRONS
A	Ata	Fokotseha
B	Ata	Fokotseha
C	Fokotseha	Ata
D	E dula e le jwalo	Ata

(2)
[20]

POTSO YA 2

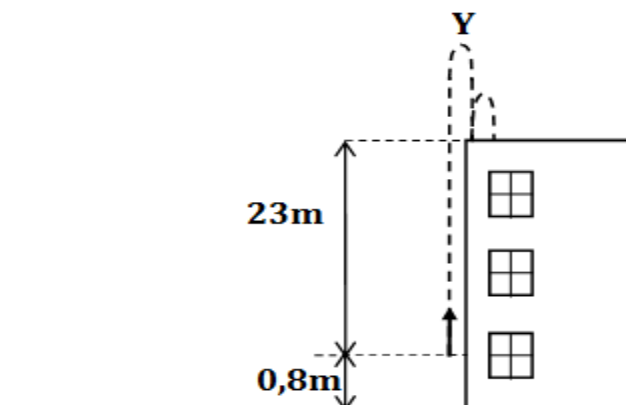
Boloko e nang le mass **4 kg** e eme ho rough horizontale safeise. Boloko e hokahantswe ho boloko e nngwe ya mass **3 kg** ka tshebediso ya setring se bobebe se sa sarolloheng e leketla hodima pulley e se nang frikishene. Safeisi e ekesetha force ya 12,5 N phephenditjhula ho safeisi ya 4 kg boloko. Force ya **72 N** e apolauwe ho 4 kg boloko ka enkele θ ho horizontale jwalo ka ha ho bontshitswe tayakeramong e ka tlase. Sisetemo e akeselereitela ka ho le Letona. Coefficient ya kinetic friction dipakeng tsa safeise le 4 kg boloko ke 0,25. Se natse phepetso ya air friction.



- 2.1 Fana ka lentswe le le leng kapa polelwana e hlalose mantsoe a sehelleltsweng. (1)
 - 2.2 Khaletjhuleitha enkele θ . (2)
 - 2.3 Teroya free-body tayakeramo e leibotsweng o bontshe diforce TSOHLE tse ekethang ho **4 kg block**. (5)
 - 2.4 Hlalosa Newton's Second law ka mantsoe. (2)
 - 2.5 Apolaya Newton's Second Law bolokong ka nngwe ka ho arohaneng o be o khaletjhuleithe magnitude ya akeselereishene ya diboloko. (6)
- [16]**

POTSO YA 3

Moshemane o rahela hodimo bolo ya mass 700 g vethikhale ho tloha ho height ya 8 m ka hodima graonde. Bolo e feta bokahodimo ba moaho, 23 m bophahamong bo ka hodimo ba poente eo a e rahileng bolo a le ho yona. Bolo e a wa e otle marulelo a moaho ka morao ho 3,5 s hoba e rahuwe. Bolo e bhaonsa ha nngwe marulelong a moaho mme e tlo ema marulelong a moaho. Se natse phepetso ya air friction



- 3.1 Ngola magnitude le daerekeshene ya akeselereishene ya bolo ho poente Y e bontshitsweng sketjheng se ka hodimo. (1)
- 3.2 Khaletjhuleitha:
 - 3.2.1 Magnitude ya velosithi eo bolo e rahuweng ka yona (3)
 - 3.2.2 Makesemamo height eo bolo e e fihleletseng ka hodima graonde (4)
 - 3.2.3 Velosithi eo bolo e otlang maroleo lekgetlong la pele (3)
- 3.3 Ka ho ikamahanya le sketjhe feela , hlalosa hore ebe kholejene ya bolo le marulelo e ELASTIC kapa INELASTIC. Hlalosa karabo. (2)
- 3.4 Bolo e tloha marulelong ka velosithi ya $6,3 \text{ m} \cdot \text{s}^{-1}$ ka mora ho bhaonsa marulelong. Khaletjhuleitha nete force e ekesethuweng bolong ke marulelo haeba bolo e ne e dutse 0,01 s marulelong. (4)
- 3.5 Sketjha position versus time kerafo ya moushene e felletseng ya bolo, ho tloha ha e ne e rahuwa ho fihlela e ema ka mora ho bhaonsa. Sebedisa bokahodimo ba marulelo e le **zero position**.

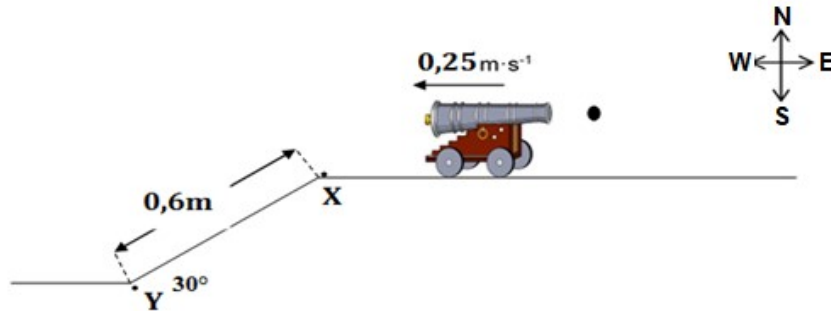
Bontsha tse latelang ka ho hlakileng kerafong:

- Posishene ya bolo ha moshemane a e raha.
- Posishene ya bolo ho poente Y.
- Nako eo bolo e otlang marulelo lekgetlo la pele.

(3)
[20]

POTSO YA 4

Canon ya thoye, ya mass $1,8 \text{ kg}$, e eme ho rough horizonthale safeise jwalo ka ha ho bontshitswe tayakeramong e ka tlase. Steel ball, ya mass $0,07 \text{ kg}$, e thuntswe horizonthale ho ya east ho tloha ho canon. Hanghang ka mora ho thunngwa ha bolo, canon e ya west ka $0,25 \text{ m}\cdot\text{s}^{-1}$.



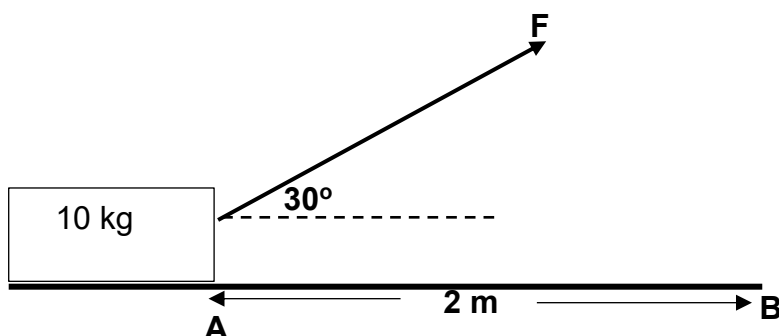
- 4.1 Bolela prinsipole ya conservation ya linear momentum ka matswe. (2)
- 4.2 Khaletjhuleitha sepiti sa steel ball hanghang ka mora hoba e thuntswe. (3)
- 4.3 Dikoloi tsa sejwalejwale di na le airbag e etseditsweng ho fokotse dikotsi ho bapalami nakong ya kholeshene. Hlalosa hore di-airbag di fokotsa jwang dikotsi ho bapalami nakong ya kholejene. (2)
- 4.4 Canon e fihlella poente **X** ka sepiti sa $0,25 \text{ m}\cdot\text{s}^{-1}$ e boele e ye tlase ho inclined safeise **XY** $0,6 \text{ m}$ e ho enkele ya 30° ho horizonthale jwalo ka ha ho bontshitswe tayakeramong e ka tlase. Frictional force dipakeng tsa safeise le canon ke $1,85 \text{ N}$.

Sebedisa di-**ENERGY PRINCIPLE** feela, o khaletjhuleithe velosithi ya canon ho poente **Y**, e tlase ho inclined safeise.

(5)
[12]

POTSO YA 5

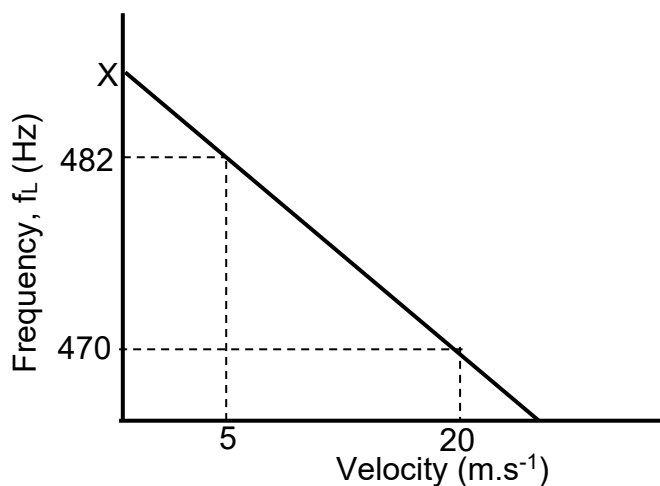
Constant force **F** e apolauwa ho enkele ya 30° ho horizonthale hodima crate ya mass 10 kg e qadileng e eme, jwalo ka ha ho bontshitswe tayakeramong e ka tlase. Constant frictional force ya 10 N e eketha ho crate e ntse e tsamaya ho horizonthale safeise ho tloha ha e ne e eme ho poente **A** e ya ho poente **B**. Distance dipakeng tsa poente **A** le poente **B** ke 2 m. Sepiti sa crate ho poente **B** ke $2 \text{ m}\cdot\text{s}^{-1}$.



- 5.1 Hlalosa themo *non-conservative force*. (2)
- 5.2 Sebedisa di-ENERGY PRINCIPLE FEELA, o khaltjhuleithe magnitude ya force **F**. (4)
- 5.3 Jwale 2 kg objekethe e beuwe ho crate. Ke efe tshusumetso e entsweng ke phetoho ho work done ke force **F** e tshwanang ha crate e tsamaiswa hape ho tloha ho poente **A** ho ya ho poente **B**? Ngola feela e a ATA, FOKOTSEHA kapa DULA E LE JWALO. (2)
- [8]**

POTSO YA 6

Fire truck e nang le saerene e llang e tsamaya tseleng e setereiti e horizonthale. Detector e beuweng lehlakoreng la tsela e rekhoda frequency ya modumo wa saerene le velosithi ya fire truck. Divelu tse sebedisitsweng ho fumana kerafo e ka tlase, E SA TEROYWANG HO YA KA SEKEILE. Nka velosithi ya moya e le 340 m.s^{-1} .

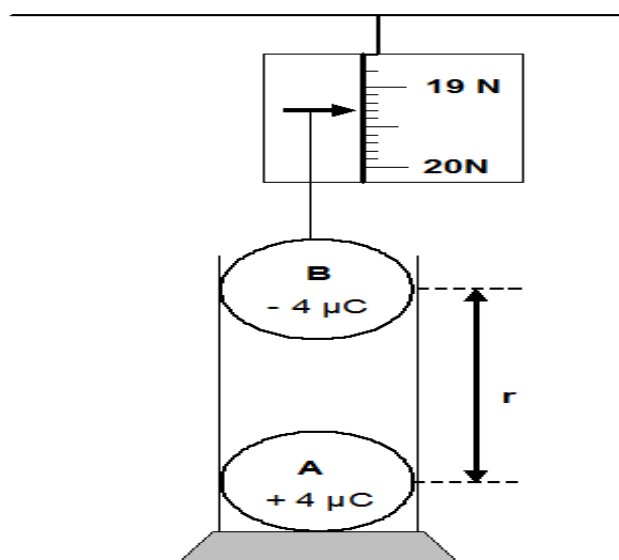


- 6.1 Hlalosa fenomenone e emetsweng kerafong e ka hodimo. (2)
- 6.2 Ana fire truck e tsamaya HO ATAMELA kapa E YA HOLE LE detector? Hlalosa karabo ya hao. (2)
- 6.3 Ngola kamano dipakeng tsa velosithi ya fire truck le frequency e obsevuweng. (2)
- 6.4 X, e leng intercept ho vethikhole akisisi, o emetse eng? (2)
- 6.5 Khaltjhuleitha frequency ya saerene ya fire truck. (5)

[13]

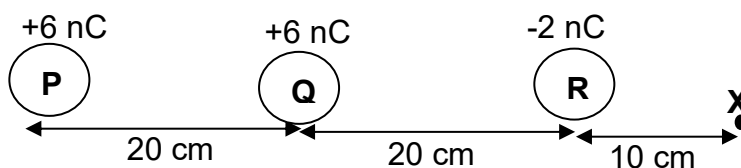
POTSO YA 7

Sphere **A** se na le tjhatjhe ya $+4 \mu\text{C}$ mme se beuwe ho insulated cylinder. Sphere **B** sa bobedi se ayedenthikhale, se nang le tjhatjhe e ophosithi le mass 500 g , se leketla vethikhale se eme hantle hodima sphere **A** ka distance r . Sphere **B** se hokantswe ho sekeile jwalo ka ha ho bontshitswe tayakeramong e ka tlase.



- 7.1 Teroya electric field pattern e etsuwang ke di-sphere **A** le **B**. (3)
- 7.2 Ke eng magnitude ya upward force e ekethang ho sphere **B**? (1)
- 7.3 Khletjhuleitha distance r dipakeng tsa di-sphere **A** le **B**. (5)

Tayakeramo e ka tlase e bontsha di-insulated metal sphere tse tharo tse ayedenthikhale. Di-sphere **P** le **Q** ka nngwe di na le tjhatjhe ya 6 nC le **R** e nang le tjhatjhe ya -2 nC . Poente **X** ke 10 cm ka ho le letona ho **R** jwalo ka ha ho bontshitswe tayakeramong e ka tlase.

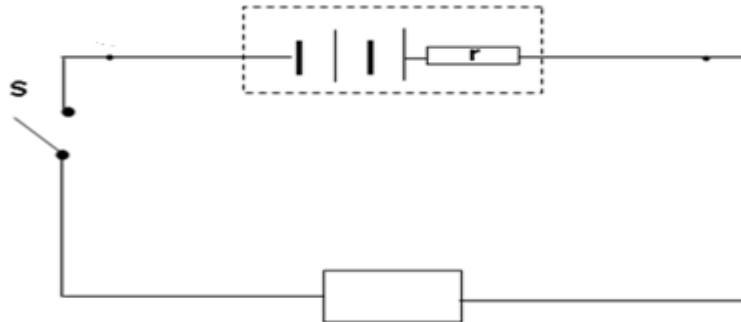


- 7.4 Hlalosa *electric field at a point* ka mantswe. (2)
- 7.5 Khalejhuleitha net electric field ho poente **X** e etsuwang ke di-sphere **P**, **Q** le **R**. (5)

[16]

POTSO YA 8

Baithuti ba Kereiti 12 ba khondakthile ekeseperimente ho fumana emf, $\mathcal{E}$ le internal resistance r ya battery ka ho hokela di-resistor tse tharo e nngwe ka mora e nngwe ho sekethe tayakeramo e ka tlase. Nako e nngwe le e nngwe ba bala ba be ba rekhode reading ya voltmitha le amitha.

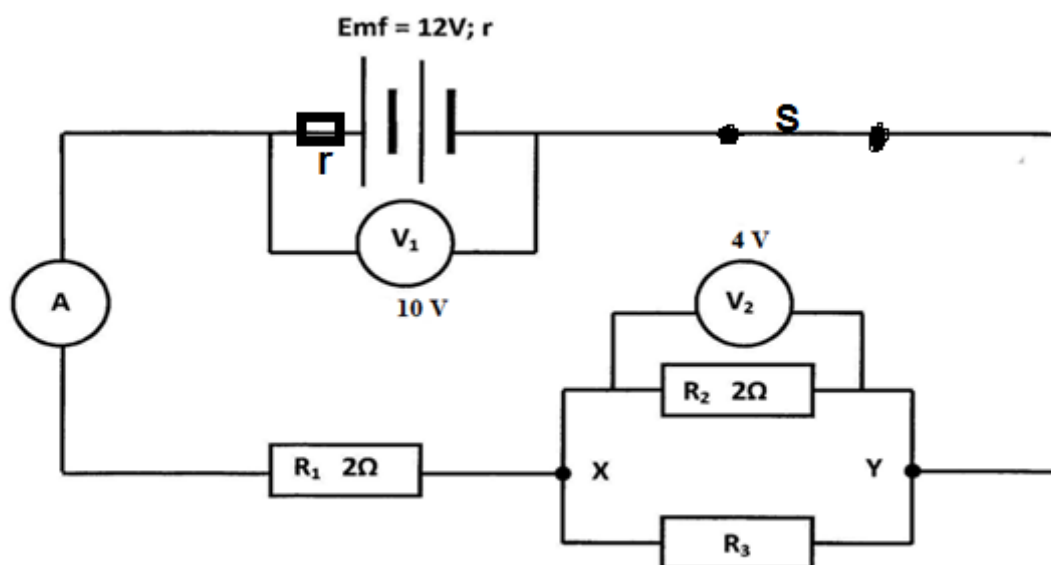


Di-reading tse fumanweng direkhoduwe theiboleng e ka tlase:

Number of resistors	Voltmeter reading (V)	Ammeter reading (A)
1	7,8	3,5
2	9,6	2,0
3	10,2	1,5

- 8.1 Sketjha sekethe ena BUKENG YA DIKARABO. Seketjheng sa hao, bontsha moo baithuti ba hoketseng amitha le voltmitha. (2)
- 8.2 Hlalosa themo *emf* ya battery. (2)
- 8.3 Khaletjhuleitha emf, $\mathcal{E}$ ya battery, ho ya ka diphetho tsa phuputso ya bona. (6)

- 8.4 Ho sekethe tayakeramo e bontshitsweng ka tlase, battery e na le internal resistance e sa tsebisahaleng le emf ya 12 V. Ha kharente e flowa ho sekethe, voltmitha akhrose battery V_1 e bala 10 V le voltmitha akhrose R_2 V_2 e bala 4 V.



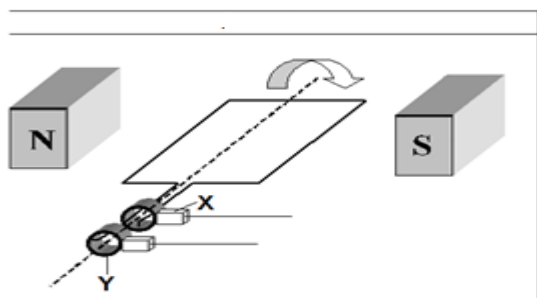
Khaltjhuleitha:

- 8.4.1 Resistense ya resistor R_3 (6)
- 8.4.2 Internal resistance ya battery (3)
- 8.5 Jwale R_3 o tloswa ho sekethe mme a repoleiswe ka wire e nang le resistance e sa tsotellwang. Ke efe tshusumetso ho reading ya V_1 . Ngola e a ATA, FOKOTSEHA kapa DULA E LE JWALO. Hlalosa karabo ya hao. (3)

[22]

POTSO YA 9

Simplifaete tayakeramo e ka tlase e bontsha alternating current (AC) generator e rotheithuweng tlelokhwaese.



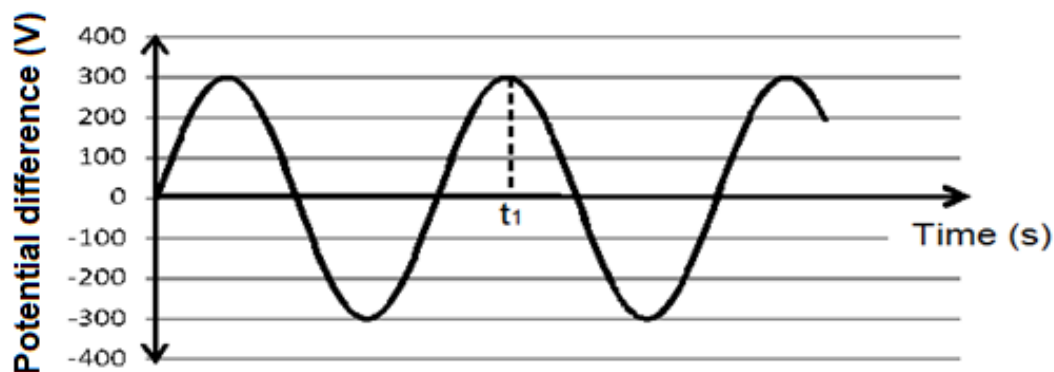
9.1 Ngola energy conversion e etsehang ho AC generator. (1)

9.2 Ngola lebitso la dikhomponente tse latelang:

9.2.1 X (1)

9.2.2 Y (1)

9.3 Maximum current output ya AC generator ena ke 21 A. Kerafo ya potential difference output ya jenereitha against time e bontshitswe ka tlase.



9.3.1 Hlalosa themo *root mean square (rms) potential difference*. (2)

9.3.2 Khaletjhuleitha avereije phawa output ya jenereitha ena. (5)

[10]

POTSO YA 10

Baithuti ba phefoma ekseperimente ho fuputsa tshusumetso ya wavelength ya laete ho photo-electric effect. Ba irradiyeitha methale safeise **M** ka mehlodi e meraro ya laete ya diwavelength tse fapaneng mme ba hlokomela ejekeshene ya di-photoelectron ho methale safeise.

Diphetho tse fumanweng di bontshitswe theiboleng e ka tlase:

MOHLODI WA LAETE	WEIVELENTHE ($\times 10^{-9}$ M)	EJEKESHENE YA DI- PHOTOELECTRON
A	480	Di-electron di ejekethuwa di be di ye hole le methale
B	620	Ha ho di-electron tse ejekethuweng
C	570	Di-electron di ejekethuwa di be di SE KE tsa tloha ho methale

10.1 Hlalosa *photo-electric effect* ka mantswe. (2)

10.2 Fana ka lebaka hobaneng mohlodi wa laete **B** o sa ka wa ejeketha di-electron ho tloha ho methale safeise **M**. (2)

10.3 Khaltjhuleitha:

10.3.1 Work function ya methale **M**. (3)

10.3.2 Makesemamo sepiti seo di-electron di tla ejekethuwa ho methale safeise **M** ha e irradiethuwe ka mohlodi wa laete **A**. (5)

10.4 Mohlodi wa laete **A** ke BLUE laete le mohlodi wa laete **B** ke ORANGE laete. Ke ofe mmala o ka bang mohlodi wa laete **C**?

Kgetha dipakeng tsa VIOLET, GREEN kapa RED feela. (1)

[13]

MATSHWAO KAOFELA: 150

DATA FOR PHYSICAL SCIENCES GRADE 12

PAPER 1 (PHYSICS)

DATHA YA FISIKALE SAENSESE KEREITI 12

PAMPIRI 1 (FISIKISI)

TABLE 1: PHYSICAL CONSTANTS/THEIBOLE 1: FISIKALE KONSETENTE

NAME/LEBITSO	SYMBOL/ SIMBOLE	VALUE/VELU
Acceleration due to gravity / <i>Akeselereishene ya gravity</i>	g	$9,8 \text{ m}\cdot\text{s}^{-2}$
Universal gravitational constant / <i>Universale gravitheshinale konsetente</i>	G	$6,67 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
Speed of light in a vacuum / <i>Sepiti sa laete ho vakum</i>	c	$3,0 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Planck's constant / <i>Planck konsetente</i>	h	$6,63 \times 10^{-34} \text{ J}\cdot\text{s}$
Coulomb's constant / <i>Coulomb konsetente</i>	k	$9,0 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$
Charge on electron / <i>Tjhatjhe ho electron</i>	e	$-1,6 \times 10^{-19} \text{ C}$
Electron mass / <i>Electron mass</i>	m_e	$9,11 \times 10^{-31} \text{ kg}$
Mass of earth / <i>Massa ya earth</i>	M	$5,98 \times 10^{24} \text{ kg}$
Radius of earth / <i>Radius ya earth</i>	R_E	$6,38 \times 10^6 \text{ m}$

TABLE 2: FORMULAE/THEIBOLE 2: DI-FOMULA

MOTION/MOUSHENE

$v_f = v_i + a \Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ or/kapa $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$v_f^2 = v_i^2 + 2a\Delta x$ or/of $v_f^2 = v_i^2 + 2a\Delta y$	$\Delta x = \left(\frac{v_i + v_f}{2} \right) \Delta t$ or/kapa $\Delta y = \left(\frac{v_i + v_f}{2} \right) \Delta t$

FORCE/FORCE

$F_{\text{net}} = ma$	$p = mv$
$f_s^{\text{max}} = \mu_s N$	$f_k = \mu_k N$
$F_{\text{net}} \Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = \frac{Gm_1m_2}{d^2}$	$g = G \frac{M}{d^2}$

WORK, ENERGY AND POWER/WEKE, ENEJI LE PHAWA

$W = F \Delta x \cos \theta$	$U = mgh$ or/kapa $E_p = mgh$
$K = \frac{1}{2}mv^2$ or/kapa $E_k = \frac{1}{2}mv^2$	$W_{\text{nett}} = \Delta K$ or/kapa $W_{\text{nett}} = \Delta E_k$ $\Delta K = K_f - K_i$ or/kapa $\Delta E_k = E_{kf} - E_{ki}$
$W_{\text{nc}} = \Delta K + \Delta U$ or/kapa $W_{\text{nc}} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{\text{ave}} = FV_{\text{ave}}$	

WAVES, SOUND AND LIGHT/WEIVE, MODUMO LE LAETE

$v = f \lambda$	$T = \frac{1}{f}$
$f_L = \frac{v \pm v_L}{v \pm v_s} f_s$ $f_L = \frac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or/kapa $E = h \frac{c}{\lambda}$
$E = W_o + E_{k(\text{max})}$ OR $E = W_o + K_{\text{max}}$ where/moo $E = hf$ and/le $W_o = hf_o$ and/le $E_{k(\text{max})} = \frac{1}{2}mv_{\text{max}}^2$ or/of $K_{(\text{max})} = \frac{1}{2}mv_{\text{max}}^2$	

ELECTROSTATICS/ELEKETROSETATOKESE

$F = \frac{kQ_1Q_2}{r^2}$	$E = \frac{kQ}{r^2}$
$V = \frac{W}{q}$	$E = \frac{F}{q}$
$n = \frac{Q}{q_e}$ OR $n = \frac{q}{e}$	

ELECTRIC CIRCUITS/ELEKETRIKI SEKETE

$R = \frac{V}{I}$	$\text{emf } (\mathcal{E}) = I(R + r)$
$R_s = R_1 + R_2 + R_3 + \dots$ $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$	$Q = I\Delta t$
$W = Vq$ $W = VI\Delta t$ $W = I^2 R \Delta t$ $W = \frac{V^2 \Delta t}{R}$	$P = \frac{W}{\Delta t}$ $P = VI$ $P = I^2 R$ $P = \frac{V^2}{R}$

ALTERNATING CURRENT/ALTERNATING CURRENT

$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}} \quad / \quad I_{\text{wgk}} = \frac{I_{\text{maks}}}{\sqrt{2}}$ $V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}} \quad / \quad V_{\text{wgk}} = \frac{V_{\text{maks}}}{\sqrt{2}}$	$P_{\text{average}} = V_{\text{rms}} I_{\text{rms}} \quad / \quad P_{\text{gemiddeld}} = V_{\text{wgk}} I_{\text{wgk}}$ $P_{\text{average}} = I_{\text{rms}}^2 R \quad / \quad P_{\text{gemiddeld}} = I_{\text{wgk}}^2 R$ $P_{\text{average}} = \frac{V_{\text{rms}}^2}{R} \quad / \quad P_{\text{gemiddeld}} = \frac{V_{\text{wgk}}^2}{R}$
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