



## **Education and Sport Development**

Department of Education and Sport Development  
Departement van Onderwys en Sportontwikkeling  
Lefapha la Thuto le Tlhabololo ya Metshameko

**NORTH WEST PROVINCE**

**NATIONAL  
SENIOR CERTIFICATE/  
NASIONALE  
SENIOR SERTIFIKAAT**

**GRADE/GRAAD 12**

**PHYSICAL SCIENCES: PHYSICS (P1)/  
FISIESE WETENSKAPPE: FISIKA (V1)**

**SEPTEMBER 2017**

**MEMORANDUM**

**MARKS/PUNTE: 150**

**This memorandum consists of 11 pages./  
Hierdie memorandum bestaan uit 11 bladsye.**

**GENERAL MARKING GUIDELINES PAPER 1**  
**ALGEMENE NASIENRIGLYNE VRAESTEL 1**

**1. CALCULATIONS/BEREKENINGE**

- 1.1 Marks will be awarded for:** correct formula, correct substitution, correct answer with unit.  
*Punte sal toegeken word vir: korrekte formule, korrekte substitusie, korrekte antwoord met eenheid.*
- 1.2 No marks will be awarded if an incorrect or inappropriate formula is used,** even though there may be relevant symbols and applicable substitutions. When an error is made during **substitution into a correct formula**, a mark will be awarded for the correct formula and for the correct substitutions, but **no further marks will be given.**  
*Geen punte sal toegeken word waar 'n verkeerde of ontoepaslike formule gebruik word nie, selfs al is daar relevante simbole en relevante substitusies. Wanneer 'n fout gedurende substitusie in 'n korrekte formule begaan word, sal 'n punt vir die korrekte formule en vir korrekte substitusies toegeken word, maar geen verdere punte sal toegeken word nie.*
- 1.3 If no formula is given, but all substitutions are correct,** a candidate will **forfeit one mark.**  
*Indien geen formule gegee is nie, maar al die substitusies is korrek, verloor die kandidaat een punt.*
- 1.4 No penalisation if zero substitutions are omitted in calculations where correct formula/principle is given correctly.**  
*Geen penallisering indien nulwaardes nie getoon word nie in berekeninge waar die formule/beginsel korrek gegee is nie.*
- 1.5 Mathematical manipulations and change of subject of appropriate formulae carry no marks,** but if a candidate starts off with the correct formula and then changes the subject of the formula incorrectly, marks will be awarded for the formula and the correct substitutions. The mark for the incorrect numerical answer is forfeited.  
*Wiskundige manipulasies en verandering van die onderwerp van toepaslike formules tel geen punte nie, maar indien 'n kandidaat met die korrekte formule begin en dan die onderwerp van die formule verkeerd verander, sal punte vir die formule en korrekte substitusies toegeken word. Die punt vir die verkeerde numeriese antwoord word verbeur.*
- 1.6 Marks are only awarded for a formula if a calculation has been attempted,** i.e. substitutions have been made or a numerical answer given.  
*Punte word slegs vir 'n formule toegeken indien 'n poging tot 'n berekening aangewend is, d.w.s. substitusies is gedoen of 'n numeriese antwoord is gegee.*
- 1.7 Marks can only be allocated for substitutions when values are substituted into formulae and not when listed before a calculation starts.**  
*Punte kan slegs toegeken word vir substitusies wanneer waardes in formule ingestel is en nie vir waardes wat voor 'n berekening gelys is nie.*
- 1.8 All calculations, when not specified in the question, must be done to a minimum of TWO decimal places.**  
*Alle berekenings, wanneer nie in die vraag gespesifiseer word nie, moet tot 'n minimum van twee desimale plekke gedoen word.*

- 1.9 If a final answer to a calculation is correct, full marks will not automatically be awarded. Markers will always ensure that the correct/appropriate formula is used and that workings, including substitutions, are correct.

*Indien 'n finale antwoord van 'n berekening korrek is, sal volpunte nie outomaties toegeken word nie. Nasieners sal altyd verseker dat die korrekte/toepaslike formule gebruik word en dat bewerkings, insluitende substitusies korrek is.*

- 1.10 Questions where a series of calculations have to be made (e.g. a circuit diagram question) do not necessarily always have to follow the same order. FULL MARKS will be awarded provided it is a valid solution to the problem. However, any calculation that will not bring the candidate closer to the answer than the original data, will not count any marks.

*Vrae waar 'n reeks berekenings gedoen moet word (bv. 'n stroomdiagramvraag), hoef nie noodwendig dieselfde volgorde te hê nie. VOLPUNTE sal toegeken word op voorwaarde dat dit 'n geldige oplossing vir die probleem is. Enige berekening wat egter nie die kandidaat nader aan die antwoord as die oorspronklike data bring nie, sal geen punte tel nie.*

## 2. UNITS/EENHEDE

- 2.1 Candidates will only be penalised once for the repeated use of an incorrect unit **within a question**.

*Kandidate sal slegs een keer gepeenaliseer word vir die herhaaldelike gebruik van 'n verkeerde eenheid in 'n vraag.*

- 2.2 Units are only required in the final answer to a calculation.

*Eenhede word slegs in die finale antwoord op 'n vraag verlang.*

- 2.3 Marks are only awarded for an answer, and not for a unit *per se*. Candidates will therefore forfeit the mark allocated for the answer in each of the following situations:

- Correct answer + wrong unit
- Wrong answer + correct unit
- Correct answer + no unit

*Punte word slegs vir 'n antwoord en nie vir 'n eenheid per se toegeken nie. Kandidate sal derhalwe die punt vir die antwoord in die volgende gevalle verbeur:*

- Korrekte antwoord + verkeerde eenheid
- Verkeerde antwoord + korrekte eenheid
- Korrekte antwoord + geen eenheid

- 2.4 SI units must be used except in certain cases, e.g.  $V \cdot m^{-1}$  instead of  $N \cdot C^{-1}$ , and  $cm \cdot s^{-1}$  or  $km \cdot h^{-1}$  instead of  $m \cdot s^{-1}$  where the question warrants this.

*SI-eenhede moet gebruik word, behalwe in sekere gevalle, bv.  $V \cdot m^{-1}$  in plaas van  $N \cdot C^{-1}$ , en  $cm \cdot s^{-1}$  of  $km \cdot h^{-1}$  in plaas van  $m \cdot s^{-1}$  waar die vraag dit regverdig.*

## 3. GENERAL/ALGEMEEN

- 3.1 If one answer or calculation is required, but two are given by the candidate, only the first one will be marked, irrespective of which one is correct. If two answers are required, only the first two will be marked, etc.

*Indien een antwoord of berekening verlang word, maar twee word deur die kandidaat gegee, sal slegs die eerste een nagesien word, ongeag watter een korrek is. Indien twee antwoorde verlang word, sal slegs die eerste twee nagesien word, ens.*

- 3.2 For marking purposes, alternative symbols (s, u, t, etc.) will also be accepted.

*Vir nasiendoelindes sal alternatiewe simbole (s, u, t, ens.) ook aanvaar word.*

3.3 Separate compound units with a multiplication dot, not a full stop, for example,  $m \cdot s^{-1}$ . For marking purposes  $m \cdot s^{-1}$  and  $m/s$  will also be accepted.  
*Skei saamgestelde eenhede met 'n vermenigvuldigpunt en nie met 'n punt nie, byvoorbeeld,  $m \cdot s^{-1}$ . Vir nasiendoelindes sal  $m \cdot s^{-1}$  en  $m/s$  ook aanvaar word.*

#### 4. POSITIVE MARKING

Positive marking regarding calculations will be followed in the following cases.

*Positiewe nasien met betrekking tot berekenings sal in die volgende gevalle geld:*

4.1 **Sub question to sub question:** When a certain variable is incorrectly calculated in one sub question (e.g. 3.1) and needs to be substituted into another sub question (3.2 or 3.3), **full marks** are to be awarded for the subsequent sub questions.

*Subvraag na subvraag: Wanneer 'n sekere veranderlike in een subvraag (bv. 3.1) bereken word en dan in 'n ander vervang moet word (3.2 of 3.3), bv. indien die antwoord vir 3.1 verkeerd is en word korrek in 3.2 of 3.3 vervang, word volpunte vir die daaropvolgende subvraag toegeken.*

4.2 **Multi-step question in a sub question:** If the candidate has to calculate, for example, current in the first step and gets it wrong due to a substitution error, the mark for the substitution and the final answer will be forfeited.

*'n Vraag met veelvuldige stappe in 'n subvraag: Indien 'n kandidaat byvoorbeeld, die stroom verkeerd bereken in 'n eerste stap as gevolg van 'n substitusiefout, verloor die kandidaat die punt vir die substitusie sowel as die finale antwoord.*

#### 5. NEGATIVE MARKING/NEGATIEWE NASIEN

Normally an incorrect answer cannot be correctly motivated if based on a conceptual mistake. If the candidate is therefore required to motivate in QUESTION 3.2 the answer given to QUESTIONS 3.1, and 3.1 is incorrect, no marks can be awarded for QUESTION 3.2. However, if the answer for e.g. QUESTION 3.1. is based on a calculation, the motivation for the incorrect answer in QUESTION 3.2 should be considered.

*'n Verkeerde antwoord, indien dit op 'n konsepsuele fout gebaseer is, kan normaalweg nie korrek gemotiveer word nie. Indien 'n kandidaat gevra word om in VRAAG 3.2 die antwoord op VRAAG 3.1 te motiveer en 3.1 is verkeerd, kan geen punte vir VRAAG 3.2 toegeken word nie. Indien die antwoord op bv. VRAAG 3.1 egter op 'n berekening gebaseer is, kan die motivering vir die verkeerde antwoord in VRAAG 3.2 oorweeg word.*

#### QUESTION 1/VRAAG 1

- 1.1 B ✓ ✓
- 1.2 C ✓ ✓
- 1.3 B ✓ ✓
- 1.4 C ✓ ✓
- 1.5 B ✓ ✓
- 1.6 D ✓ ✓
- 1.7 D ✓ ✓
- 1.8 A ✓ ✓
- 1.9 C ✓ ✓
- 1.10 A ✓ ✓

**QUESTION 2/ VRAAG 2**

2.1 An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force/*'n Voorwerp in rus of konstante snelheid sal so bly, behalwe as 'n ongebalanseerde krag op hom inwerk.* ✓✓ (2)

2.2 Since smooth surface, no frictional force is acting on skateboard, so constant velocity/*Dit is 'n gladde oppervlakte, geen weerstand, so konstante snelheid* ✓✓ (2)

2.3.1  $f = \mu_k N \checkmark = (0,2)(9,8)(95)(\cos 30^\circ) \checkmark = \underline{161,25N} \checkmark$  (3)

2.3.2  $F_{net} = ma \checkmark \Rightarrow F_{G||} + (-f) = ma \Rightarrow (95)(9,8)\sin 30^\circ - 161,25 \checkmark = 95 a \checkmark$   
 $a = \underline{3,2 \text{ m}\cdot\text{s}^{-2}} \checkmark$  (4)

2.3.3  $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark \Rightarrow 2,1 = v_i (0,3) + (0,5)(3,2)(0,3)^2 \checkmark$   
 $v_i = 6,25 \text{ m}\cdot\text{s}^{-1}$   
 $v_f^2 = v_i^2 + 2 a \Delta x \Rightarrow 6,25^2 \checkmark = 1,2^2 + 2 (3,2) \Delta x \checkmark$   
 $\underline{\Delta x = 5,88 \text{ m}} \checkmark$  (5)

**NOTE:** If *g* instead of *a* is used in the equation, maximum 4 marks

[16]

**QUESTION 3/VRAAG 3**

3.1 In a closed system the total momentum is constant. OR The sum of momentum before collision is equal to the sum of momentum after collision in a closed system./*In 'n geslote sisteem bly die totale momentum konstant. OR Die somtotaal van die momentum voor die botsing is gelyk aan die somtotaal van die momentum na die botsing.* ✓✓ (2)

3.2  $\sum p \text{ before/voor} = \sum p \text{ after/na} \text{ or/of}$   
 $m_T v_i + m_C v_i = (m_T + m_C) v_f \checkmark \Rightarrow 1 \times 10^4(2) + (5 \times 10^3)(0) \checkmark = 1,5 \times 10^4 v_f \checkmark$   
 $v_i = \underline{1,33 \text{ m}\cdot\text{s}^{-1}} \checkmark$  (4)

3.3. The net force acting on an object is equal to the rate of change in momentum/*Die netto krag op 'n voorwerp is gelyk aan die tempo van verandering in die momentum.* ✓✓ (2)

3.4. Impulse  $\hat{=} \Delta p = m v_f - m v_i \checkmark = 1 \times 10^4(1,33) - 1 \times 10^4(2) \checkmark = -6700 \text{ N}\cdot\text{s} \checkmark$   
 $\therefore 6700 \text{ N}\cdot\text{s/ kgms}^{-1} \text{ left} \checkmark$  (4)

3.5.  $\left[ \begin{array}{l} \text{Before collision/Voor botsing } E_k = \frac{1}{2} m v^2 \checkmark = \frac{1}{2} 1 \times 10^4 (2)^2 + 0 \checkmark = 2 \times 10^4 \text{ J} \\ \text{After collision/Na botsing } E_k = \frac{1}{2} m v^2 = \frac{1}{2} 1.5 \times 10^4 (1.33)^2 \checkmark = 1.33 \times 10^4 \text{ J} \end{array} \right.$

$2 \times 10^4 \text{ J}$  is not equal to/is nie gelyk aan  $1.33 \times 10^4 \text{ J} \checkmark$  (4)

3.6 Net work done on an object is equal to the change in the kinetic energy/ $\checkmark \checkmark$   
Die netto arbeid verrig is gelyk aan die verandering in die kinetiese energie (2)

3.7  $F_{\text{net}} \cdot \Delta x \cos \theta = \Delta E_k = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \checkmark$

$3000 \cdot \Delta x \cos 180 \checkmark = 0.5(1.5 \times 10^4)(0) \checkmark - 0.5(1.5 \times 10^4)(1.33)^2 \checkmark$

$\Delta x = 4.42 \text{ m} \checkmark$

**Option/Opsie 2:**  $W_{\text{nc}} = \Delta E_k + \Delta E_p \checkmark$

$3000 \cdot \Delta x \cos 180 \checkmark = 0.5(1.5 \times 10^4)(0) \checkmark - 0.5(1.5 \times 10^4)(1.33)^2 \checkmark + 0$

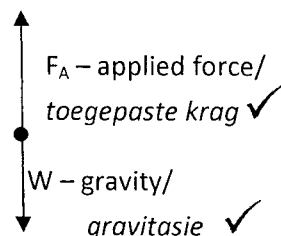
$\Delta x = 4.42 \text{ m} \checkmark$

(5)  
[23]

#### QUESTION 4/VRAAG 4

4.1 Body or object on which only force of gravity acts on while in motion/Liggaam  
of voorwerp waarop slegs gravitasiekrag inwerk $\checkmark \checkmark$  (2)

4.2.



(2)

4.3.  $F_{\text{net}} = F_A - F_g = m \cdot a \checkmark \Rightarrow F_A - (250+m)g = ma$

$7700 - 9.8(250) \checkmark - 9.8 m \checkmark = (m + 250) \cdot (6) \checkmark$

$m = 237.34 \text{ kg} \checkmark$

(5)

4.4.  $v_f^2 = v_i^2 + 2a\Delta x \checkmark = 0 + 2(6)(5) \checkmark = 60$

$v_f = 7.75 \text{ m} \cdot \text{s}^{-1} \checkmark$

(3)

**NOTE:** If  $g$  instead of  $a$  is used in the equation, maximum 2 marks

4.5.  $v_f^2 = v_i^2 + 2g\Delta x \checkmark \Rightarrow 0 = 7.75^2 + 2(-9.8)\Delta x \checkmark \Rightarrow x = 3.06 \text{ m} \checkmark$  (upward +)

$x_{\text{total}} = 3.06 + 5 = 8.06 \text{ m} \checkmark$

(4)

4.6.  $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2 \checkmark \Rightarrow -8.06 = (0) \Delta t + (0,5)(-9,8) \Delta t^2 \checkmark$

$\Delta t = 1,28 \text{ s} \checkmark$

(3)

[19]

**QUESTION 5/VRAAG 5**

5.1.1 Doppler effect/Doppler effek ✓ (1)

5.1.2 There was a relative movement between the source (ship) and the observer/  
Daar is relatiewe beweging tussen die bron (skip) en die luisteraar. ✓ ✓ (2)

5.2  $f_L = \left(\frac{v \pm v_L}{v \pm v_s}\right) f_s$  ✓

$f_s \frac{v}{v-v_s} = f_o = \frac{v}{v-v_s} f_s$

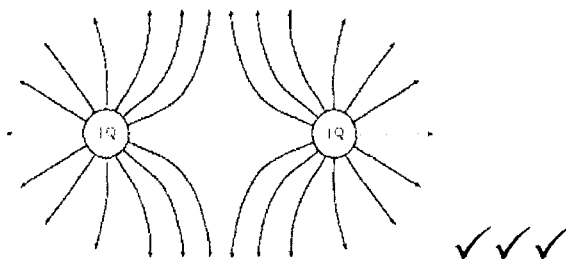
$95 \left(\frac{340}{340-6}\right) = \left(\frac{340}{340-v}\right) 94$  ✓

$v = 9.52 \text{ m.s}^{-1}$  ✓ (6)  
[9]

**QUESTION 6/VRAAG 6**

6.1 Force between two point charges are directly proportional to the product of the charges and inversely proportional to the square distance between them  
/Die krag tussen twee puntladings is direk eweredig aan die produk van die ladings en omgekeerd eweredig aan die kwadraat van die afstand tussen hulle. ✓ ✓ (2)

6.2



Mark/punte	Criteria/kriteria
1	Shape/vorm No marks for irregular shapes/geen punte vir onreëlmatige vorm.
1	Direction/rigting
1	Lines touching charge/lyne raak ladings

(3)

6.3  $F_g = \frac{k Q_1 Q_2}{r^2}$  ✓

$F_g = ma$  ✓

$0,098 = \frac{9 \times 10^9 \cdot 4 \times 10^{-6} Q_2}{0,012^2}$  ✓  $F_g = (0,01)(9,8)$  ✓

$Q_2 = 3,92 \times 10^{-10} \text{ C}$  ✓  $= 0,098 \text{ N}$  (6)  
[11]

**QUESTION 7/VRAAG 7**

7.1 Force experienced per unit positive charge near a charged object/*Krag ervaar per eenheid positiewe lading naby 'n gelaaide voorwerp.* ✓✓ (2)

$$7.2 \quad E = \frac{F}{Q} \checkmark = \frac{3 \times 10^{-6}}{-2 \times 10^{-9}} \checkmark = -1500 \text{ N.C}^{-1} = \underline{1500 \text{ N.C}^{-1}} \checkmark \quad (3)$$

$$7.3 \quad E = \frac{k Q_1}{r^2} = \frac{9 \times 10^9 (2 \times 10^{-9})}{(2 \times 10^{-2})^2} \checkmark = 45\,000 \text{ NC}^{-1}$$

$$\checkmark E = \frac{k Q_1}{r^2} = \frac{9 \times 10^9 (3 \times 10^{-9})}{(3 \times 10^{-2})^2} \checkmark = 30\,000 \text{ NC}^{-1}$$

$$E_{\text{net}} = 45\,000 + 30\,000 \checkmark = 75\,000 \text{ NC}^{-1} \checkmark \quad \text{Left/Links} \checkmark \quad (6)$$

**[11]****QUESTION 8/VRAAG 8**

$$8.1 \quad \frac{1}{R} = \frac{1}{r} + \frac{1}{r} = \frac{1}{200} + \frac{1}{200} \checkmark = \frac{2}{200} \quad R = 100 \, \Omega$$

$$R_T = 100 + 25 \checkmark = \underline{125 \, \Omega} \checkmark \quad (3)$$

$$8.2 \quad P_{\text{av}} = \frac{V_{\text{rms}}^2}{R} \checkmark \Rightarrow 2 = \frac{V^2}{200} \checkmark \Rightarrow V = \underline{20 \text{ V}} \checkmark \quad (3)$$

$$8.3 \quad I_{\text{rms}} = \frac{V_{\text{rms}}}{R} \checkmark = \frac{20}{100} \checkmark = 0,2 \text{ A}$$

$$I_{\text{max}} = I_{\text{rms}} \sqrt{2} = 0,2 \sqrt{2} \checkmark = \underline{0,28 \text{ A}} \checkmark \quad (4)$$

$$8.4 \quad V_{\text{rms}} = I_{\text{rms}} R \checkmark = (0,2)(125) \checkmark = 25 \text{ V} \checkmark \quad (3)$$

8.5.1 Increases/*Verhoog* ✓ (1)

8.5.2 The total resistance in the circuit decreases ✓ so the current increases, hence the potential difference will also increase ✓ /*Die totale weerstand in die stroombaan verlaag, so die stroom verhoog, so potensiaalverskil sal ook verhoog.* (2)

**[16]****QUESTION 9/VRAAG 9**

9.1 Resistance inside a battery that causes the potential difference to drop as a current pass through the battery ✓✓ /*Die weerstand in die battery wat die potensiaalverskil laat afneem wanneer 'n stroom deur die battery vloei.* (2)

$$9.2 \quad E = V_R + V_r \checkmark \Rightarrow 12 \checkmark = V_R + (800)(5 \times 10^{-3}) \checkmark \Rightarrow V_R = 12 - 4 = \underline{8 \text{ V}} \checkmark \quad (4)$$

$$9.3 \quad P = I^2 r \checkmark = (800)^2 (5 \times 10^{-3}) \checkmark = 3200 \text{ W} \checkmark \text{ or}$$

$$P = VI \checkmark = (4)(800) \checkmark = 3200 \text{ W} \checkmark \quad (3)$$

9.4 The current will be less, due to the lost volts in the battery, so you might not be able to start the motor car ✓✓ /*Die stroom sal laer wees a.g.v. die verlore volts in die battery, dus sal jy moontlik nie motor aan die gang kan sit nie.* (2)

**[11]**



**QUESTION 10/VRAAG 10**

10.1 Different metal atoms attract the electrons in the highest energy levels by different forces, first ionisation energy ✓ / *Verskillende metale se atome het verskillende kragte op elektrone in die hoogste energievlakke, eerste ionisasie energie.* (1)

10.2  $E = hf = h\frac{c}{\lambda} = W_o + E_k$  ✓

$$(6,63 \times 10^{-34})\left(\frac{3 \times 10^8}{2,3 \times 10^{-7}}\right) \checkmark = W_o + \frac{1}{2}(9,11 \times 10^{-31})\checkmark (4,8 \times 10^5)^2 \checkmark$$

$$W_o = 8,65 \times 10^{-19} - 1,05 \times 10^{-19}$$

$$W_o = \underline{7,60 \times 10^{-19} \text{ J}} \checkmark$$

Metal X is Silver ✓ (6)

10.3 Particle theory of light / *Deeltjieteorie van lig.* ✓ (1)

10.4.1 Increases / *Verhoog* ✓ (1)

10.4.2 Remains the same / *Bly dieselfde* ✓ (1)

10.5.1 Ultraviolet light / *Ultraviolet lig* ✓ (1)

10.5.2 High energy waves or high frequency / *Hoë-energie Hoë frekwensie golwe* ✓ (1)

10.6 Emission spectrum consist of bright lines or colours ✓ of different frequencies or wavelengths emitted during the transition of electrons from high energy to low energy in excited atoms ✓ / *Die emissiespektrum bestaan uit helder lyne of kleure van verskillende frekwensie of golflengtes wat uitgestraal word wanneer elektrone van hoë energie na lae energie beweeg in opgewekte atome.* (2)

[14]

**TOTAL/TOTAAL: 150**

## ANALYSIS GRID 2017 PHYSICAL SCIENCE P1

Question No.	Content	Taxonomy												Knowledge area				TOTAL MARKS	Question Totals	
		Knowledge, Recall, Low Demand			COMPREHENSION, Basic Questions			APPLICATION, ANALYSIS, Problem Solving			SYNTHESIS, EVALUATION, Higher Abilities, Hard new problems, Challenge Level			TOTAL	MECHANICS	WAVES, SOUND & LIGHT	ELECTRICITY & MAGNETISM			MATTER & MATERIALS
		E	M	D	E	M	D	E	M	D	E	M	D							
1.1	projectile	2												2	2				2	
1.2	projectile						2							2	2				2	
1.3	work energy		2											2	2				2	
1.4	momentum						2							2	2				2	
1.5	doppler	2												2		2			2	
1.6	emission				2									2				2	2	
1.7	electricity	2												2			2		2	
1.8	electrostatics								2					2			2		2	
1.9	electricity	2												2			2		2	
1.10	electricity					2								2			2		2	20
2.1	Newton's Law	2												2	2				2	
2.2	Newton's Law		2											2	2				2	
2.3.1	Newton's Law					3								3	3				3	
2.3.2	Newton's Law										4			4	4				4	
2.3.3	Newton's Law									5				5	5				5	16
3.1	momentum	2												2	2				2	
3.2	momentum	4												4	4				4	
3.3	momentum									2				2	2				2	
3.4	momentum					3								3	3				3	
3.5	momentum								4					4	4				4	
3.6	work energy	2												2	2				2	
3.7	work energy									5				5	5				5	23
4.1	projectile		1											2	2				2	
4.2	projectile					5								5	5				5	
4.3	projectile								3					3	3				3	
4.4	projectile	2												2	2				2	
4.5	projectile								4					4	4				4	
4.6	projectile								3					3	3				3	19
5.1.1	doppler	1												1		1			1	
5.1.2	doppler	2												2		2			2	
5.2	doppler								6					6		6			6	9
6.1	electrostatics	2												2			2		2	

6.2	electrostatics				3								3			3		3		
6.3	electrostatics					6							6			6		6	11	
7.1	electrostatics		2										2			2		2		
7.2	electrostatics								3				3			3		3		
7.3	electrostatics								6				6			6		6	11	
8.1	ohm's law						3						3			3		3		
8.2	ohm's law					3							3			3		3		
8.3	ohm's law							4					4			4		4		
8.4	ohm's law								3				3			3		3		
8.5.1	ohm's law									1			1			1		1		
8.5.2	ohm's law									2			2			2		2	16	
9.1	circuit	2											2			2		2		
9.2	circuit										4		4			4		4		
9.3	circuit								3				3			3		3		
9.4	circuit								2				2			2		2	11	
10.1	generator	1											1			1		1		
10.2	generator						6						6			6		6		
10.3	generator				1								1			1		1		
10.4.1	generator				1								1			1		1		
10.4.2	generator				1								1			1		1		
10.5.1	generator				1								1			1		1		
10.5.2	generator				1								1			1		1		
10.6	generator						2						2			2		2	14	
		21	6	0	5	19	23	12	26	23	0	15	0	150	65	12	57	16	150	150
		27			47			61			15			0	65	12	57	16		
		18.0%			31.3%			40.7%			10.0%				43.3%	8%	38%	10.7%		
		15			35			40			10				45%	8%	36%	10%		

**Overall**

E	M	D
38	66	46
25	44	31
%	%	%
30	40	30