Hong Kong Examinations and Assessment Authority & Curriculum Development Institute, EDB
Teachers' Meeting for HKDSE Physics SBA

Date : 2nd November, 2013 (Saturday)
Time : 9:30 a.m. to 11:30 a.m.
Venue : Lung Kong WFSL Lau Wong Fat Secondary School

Programme :

Time	Events
9:30 a.m. – 9:40 a.m.	Registration
9:40 a.m. – 10:10 a.m.	Introduction - 2013 SBA moderation - 2014 + 2015 SBA requirements - Plagiarism handling procedures **Mr SZETO Yuk Tong** (HKEAA)
10:10 a.m. – 10:40 a.m.	Supervisors' remarks - 2013 SBA Supervisors' Report - Detailed report requirements **Dr LAU Yiu Hon** (EDB)
10:40 a.m. – 11:05 a.m.	HKDSE SBA administration - 2014 S5&S6 SBA marks online submission **Ms Tansy CHUN** (HKEAA)
11:05 a.m. – 11:30 a.m.	Q&A

List of Documents

1. HKDSE SBA arrangement, Resource Materials and Useful Websites
2. 2013 A/AS Physics Practical Examination (Paper 4)
3. PowerPoint presentations
4. Detailed experimental report – Format and Sample
5. List of suggested experimental work for SBA
6. Experiments contributed from teachers (Mr Law Man Wai, Mr Chung On Wing & "THE PHYSICS TEACHER")
7. Most favourable distractors (2012-2013 HKDSE Physics multiple-choice questions)

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List of District Coordinators

Gp. No.	District Co-ordinators	Gp. No.	District Co-ordinators
1.	Mr. MUI Yuen Hung (梅元鴻)	13.	Dr. LAU Yiu Hon (劉耀漢)
2.	Mr. CHU Wing Yin (朱永賢)	14.	Mr. HONG Chung Yin (康仲賢)
3.	Mr. CHIK Kin Hang (戚堅鏗)	15.	**Mr. HO Yau Sing (何有勝)** †
4.	Mr. SHUM On-Bong (岑安邦)	16.	Mr. TAM Kwok Wai (譚國偉)
5.	Ms. LIN Chi Wan (林紫雲)	17.	Mr. WAN Ka Kit (温家傑)
6.	Dr. NG Pun Hon (吳本韓)	18.	Mr. LAU Kwok Leung (劉國良)
7.	Mr. LEUNG Ngai Chung (梁毅聰)	19.	Mr. LO Wai Pui (羅偉培)
8.	Mr. MAK Tsz Pun (麥子彬)	20.	Mr. LEE Chi Ming (李志明)
9.	Mr. CHUNG Sai Chak (鍾世澤)	21.	Mr. YUE Kwok Wah (余國華)
10.	Mr. LAW Man Wai (羅文惠)	22.	Mr. LEE Wai Kit (李維傑)
11.	Mr. LAW Chak Sang (羅澤生)	23.	**Mr. MA Chin Kay (馬展基)** †
12.	Mr. PANG King Fai (彭景暉)	24.	Mr. YING Pui Chi, Bosco (英佩詞)

† indicates change of District Co-ordinator
Co-Supervisors: Dr. LAU Yiu Hon (劉耀漢) and Dr. NG Pun Hon (吳本韓)

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Materials available on HKEAA web page (http://www.hkeaa.edu.hk/tc/sba/sba_hkdse_elective/dse_subject.html?20)

1. Handbook for School Leaders on SBA
2. SBA Teachers' Handbook
3. SBA Sample Tasks

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物理科教學資源

1. 課程資源

http://www.edb.gov.hk/en/curriculum-development/kla/science-edu/ref-and-resources/physics-curriculum-resources.html
http://www.edb.gov.hk/tc/curriculum-development/kla/science-edu/ref-and-resources/physics-curriculum-resources.html

- 2013 香港中學文憑物理科及組合科學科(物理部分)考試簡報會
- 教學要點說明 - 新高中組合科學課程(物理部分) (報考 2016 香港中學文憑考試學生適用)
- 教學要點說明 - 新高中物理課程 (報考 2016 香港中學文憑考試學生適用)
- 教學要點說明 - 新高中組合科學課程(物理部分) (報考 2014 或 2015 香港中學文憑考試學生適用)
- 教學要點說明 - 新高中物理課程 (報考 2014 或 2015 香港中學文憑考試學生適用)
- 香港中學文憑考試 物理及組合科學 (物理) 校本評核樣本作業 (實驗有關作業)
- 香港中學文憑考試 物理科 - 校本評核樣本作業 (探究研習)
- 香港中學文憑考試 物理/組合科學(物理) - 數據、公式和關係式
- 香港中學文憑考試校本評核建議物理實驗名單

2. 物理科教師專業發展及資源共享平台

- http://edblog.hkedcity.net/cdiphysics

3. 天文學和航天科學

http://www.lcsd.gov.hk/CE/Museum/Space/Education/SelfLearning/c_education_sl.htm

4. 原子世界

http://www.hk-phy.org/atomic_world/

5. 能量和能源的使用

http://www.hk-phy.org/energy/index_e.html

6. 醫學物理學

http://www.hkedcity.net/article/project/medicalphysics/

- Interactive Learning and Teaching Package for Medical Physics
  http://cd1.edb.hkedcity.net/cd/science/physics/NSS/MedicalPhysics.zip

7. 高解像度運動錄像分析 (HDMVA)

http://physics.hk/hdmva/
Tracker - http://www.cabrillo.edu/~dbrown/tracker/

教育電視資源

- http://etv.edb.gov.hk/home-c.aspx（中文版）
- http://etv.edb.gov.hk/resource_grade.aspx?id=sci&subject=129 （英文版）

- 探究研習(物理篇)

  「探究研習」是新高中物理課程其中一個的重要學與教活動。課程提供一定的課時，在教師指導下、進行相對獨立有計劃的學習經歷。學生在教師指導和實驗室技術員支援下訂定探究題目，自主設計實驗，主動進行探究，收集及分析數據作出結論。「探究研習」是通過調整教學方法，提供學生主動積極自主學習的機會，培養學生獨立思考與解決問題的能力。「探究研習」是提升學生自學能力和教師教學方法的一個平台。教師會因應學校（校本）和學生能力差異的情況，設計探究的流程、模式、課題、難度等以推行探究活動。這教育電視節目以記錄片形式，讓教師們及學者分享在學校推行「探究研習」的理念和策略，也讓學生們說出進行探究時所經歷的學習過程和所獲得到的滿足感。實驗室技術員亦分享了在「探究研習」過程中為教師及學生所提供的支援。本節目極為適合教師、學生及實驗室技術員觀看欣賞，並作為新高中物理科「探究研習」的輔助學習教材。

  - http://resources.hkedcity.net/resource_detail.php?rid=741932149 （中文播出版）
  - http://resources.hkedcity.net/resource_detail.php?rid=1858942238 （英文播出版）
  - http://resources.hkedcity.net/resource_detail.php?rid=1139923892 （學生- 中文版）
  - http://resources.hkedcity.net/resource_detail.php?rid=780251301 （學生- 英文版）

- 通訊新領域
  香港城市大學電子工程學系及毫米波國家重點實驗室陸貴文講座教授、陳志豪講座教授和薛泉教授經過十年來的努力不懈，研發無線通訊天線技術，配合國家科技發展和應用，獲得2011年度「國家科學技術獎」中，國家科學技術發明獎二等獎，為香港科研人員爭光，亦為國家作出重大貢獻。
  - http://resources.hkedcity.net/resource_detail.php?rid=19010548 （中文版）
  - http://resources.hkedcity.net/resource_detail.php?rid=116886921 （英文版）

- 透視妙法(Seeing Through the Human Body Part I)
  節目透過模擬病例介紹三種現代醫學使用的先進診斷技術，包括X射綫電腦斷層造影技術、磁共振造影技術和內窺鏡檢視技術。節目對每一種醫療檢視方法都作一個概括的介紹，同時利用三維動畫影像扼要解釋背後所應用的物理學原理，讓同學們除了認識各種掃描儀器的運作情況外，更加加深對課堂上學習的物理原理的理解，引發學習的興趣和動機。本節目極為適合教師及學生作為新高中物理科「醫學物理學」的學習教材。
  - http://resources.hkedcity.net/resource_detail.php?rid=1757173944 （中文版）
  - http://resources.hkedcity.net/resource_detail.php?rid=567576077 （英文版）

- 透視妙法(Sequel of Seeing Through the Human Body Part II)
  節目透過模擬病例介紹現代醫學使用的先進診斷技術，包括超聲波掃描技術和核子醫學檢視技術，極為適合教師及學生作為新高中物理科「醫學物理學」的學習教材。
  - http://resources.hkedcity.net/resource_detail.php?rid=617519262 （中文版）
  - http://resources.hkedcity.net/resource_detail.php?rid=111500338 （英文版）

- 天與地 (Sky and Earth)
  本節目極為適合教師及學生作為新高中物理科「天文學和航天科學」的學習教材。節目介紹從地球看天空時，透過天球模型描述天體 在空中的位置，及在不同地理緯度所觀察到的天極和天赤道的位置，包括天球的週日運動和太陽的週年運動。
  ETV Channel
  - http://etv.edb.gov.hk/resource_wmv-c.aspx?c=1&id=19279 （英文版）
  - http://etv.edb.gov.hk/resource_wmv-c.aspx?c=1&id=19277 （中文版）

  Edcity
  - http://resources.hkedcity.net/resource_detail.php?rid=1953282919 （英文版）
  - http://resources.hkedcity.net/resource_detail.php?rid=657189804 （中文版）

- 香港建築: 中學教材之建築學導引
  http://minisite.proj.hkedcity.net/hkiakit/cht/Science/index.html
  這教材是由香港建築師學會統籌，香港大學建築學院社會項目工作坊研究支援，香港特別行政區教育局提供顧問意見，商務及經濟發展局轄下創意香港贊助。教材內容適合「能量和能源的使用」單元中有關熱傳送系數、總熱傳送值和建築節能措施的學與教用途。內容包括：
  - 建築力學－歷史回顧
  - 建築的噪音控制與
  - 綜合熱傳值和熱傳系數的計算和應用
  - 模型製作工作坊－塔
  - 視像：建築節能措施 /演講廳的聲樂設計 /城市熱島效應
  - 實地考察：中環－摩天大廈的結構 /香港濕地公園－人類影響、污染控制、可持續發展和能源效益

8. 香港中學文憑考試 (校本評核/ 評核大綱)
   新聞稿：香港中學文憑考試校本評核精簡安排 (14/2/2012)
   http://www.hkeaa.edu.hk/DocLibrary/Media/PR/PR_20120214_chi.pdf
   http://www.hkeaa.edu.hk/DocLibrary/Media/PR/PR_20120214_eng.pdf

   - 香港中學文憑科目評核大綱 (至 2016)
     http://www.hkeaa.edu.hk/tc/hkdse/Assessment_Framework/

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG ADVANCED LEVEL EXAMINATION 2013
PHYSICS A-LEVEL/AS-LEVEL PAPER 4

Candidate No. _____ Bench No. _____ Total : 20 marks

Time allowed: 1 hour 30 minutes (Questions marked with * involve measurements. The first 60 minutes is for performing the experiment and all measurements must be finished within this period. The remaining 30 minutes is for writing-up.)

Warning : The switch should be open when you are not taking readings.

Objective : To measure the strength of the magnetic field between two slab-shaped magnets by studying the magnetic force on a current-carrying coil.

Apparatus : 1 battery (18 V), 1 triple beam balance with a 360° circular protractor fixed on its pan, 1 digital multimeter, 1 switch, 1 square search coil, 1 steel yoke with two slab-shaped magnets and with a pointer attached at the middle of its bottom surface, 4 connecting wires, 1 set of retort stand and clamp.

Procedures :

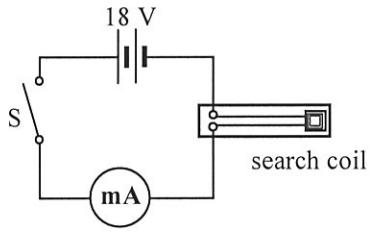
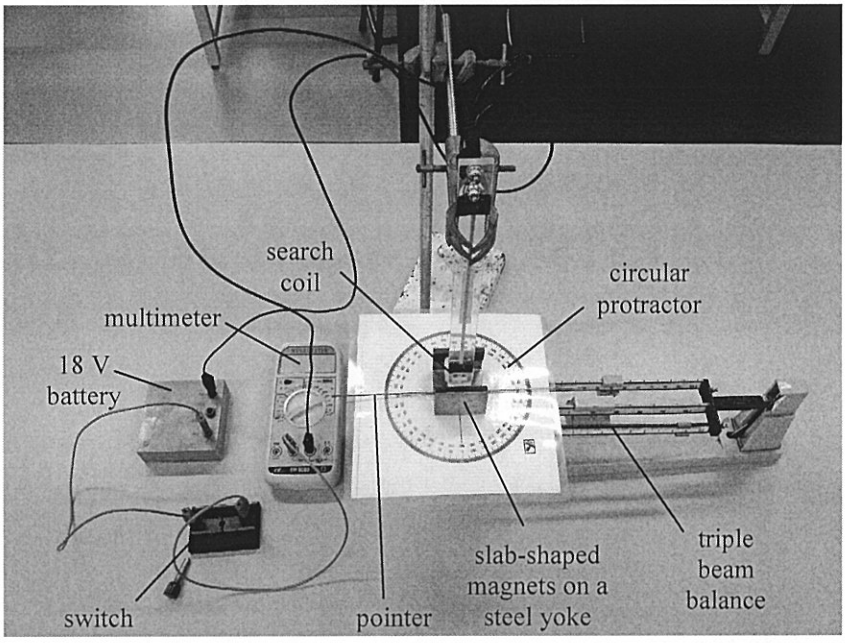
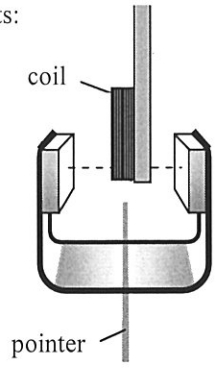


Figure 1



1. With the switch S open, set up the apparatus as shown in Figure 1 and ensure the following points:
   (a) Place the steel yoke on the protractor such that the pointer overlaps the 90° and 270° marks of the protractor.
   (b) Connect the search coil to the battery via the switch and the multimeter that serves as a milliammeter to measure the current through the coil.
   (c) With the handle of the search coil pointing vertically upwards, adjust the position of the search coil until its **bottom side** lies in-between the two slab-shaped magnets as shown. The bottom side should be horizontal and parallel to the magnets (i.e. perpendicular to the magnetic field between the magnets) but **the coil and the connecting wires should not touch anything on the balance**.

side view



Ask the Examiner to check the set-up. A short time is allowed for you to correct any faults; if you are still unable to set up the apparatus, you may ask the Examiner to set it up for you. You will lose 3 marks for this.

*2. Measure the total mass R_0 of the objects placed on the pan of the balance when there is no current in the coil. Record the reading R_0 correct to 2 decimal places in unit of gram and its error.

$R_0 =$ _____ $\pm$ _____ g

3. In this set-up, what is the angle θ between the bottom side of the search coil and the magnetic field between the magnets ?

$\theta =$ _____ °

*4. Close the switch to pass an electric current I through the coil. Record the current I and its error.

$I =$ _____ $\pm$ _____ mA

*5. Due to the current I, there is a magnetic force $\boldsymbol{F}$ acting on the bottom side of the coil. As a result, the triple beam loses its balance (i.e. the pointer of the balance deviates from the zero mark). Restore its balance and then take the balance reading R and its error. Explain how the readings R_0 and R can be used to estimate the magnitude of $\boldsymbol{F}$.

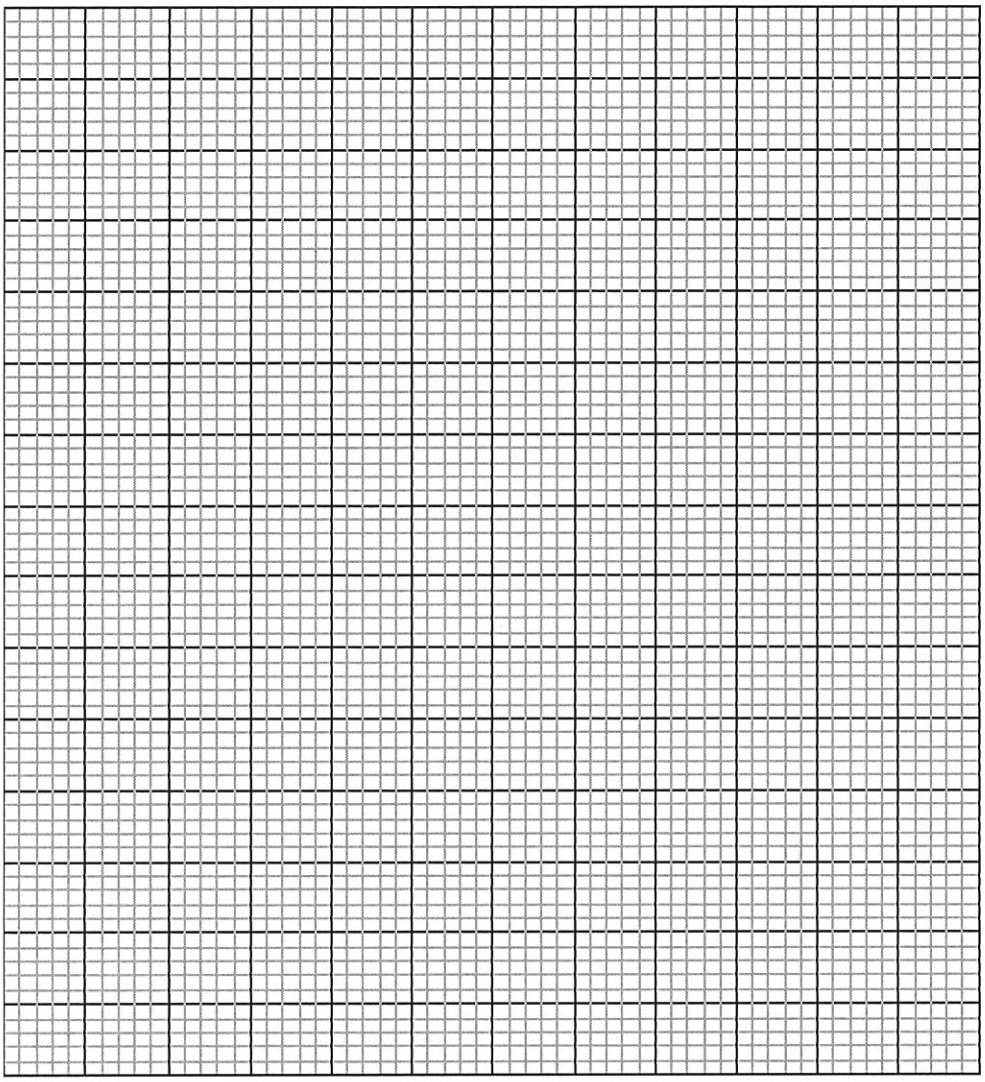
$R =$ _____ $\pm$ _____ g

6. The number of turns N of the search coil and the length ℓ of its bottom side are 5000 and 2.0 cm respectively. Take the gravitational acceleration g as 9.81 m s^{-2}. Use the data obtained to estimate the strength B of the magnetic field between the two slab-shaped magnets. Show your steps clearly and state any assumption related to the estimation of magnetic field strength. Given: force on a current-carrying conductor in a magnetic field is $BI\ell \sin\theta$ where θ is the angle between the conductor and the magnetic field.

7. Estimate the error in the value of B found in Question 6. Neglect the errors in N, ℓ and g.

*8. By changing the orientation of the steel yoke alone, repeat the procedures in Questions 4 and 5 until you get 7 sets of readings for θ and R. Then complete the following table and plot a graph of $|R - R_0|$ against $\sin\theta$.

θ	90°	65°	45°	30°	20°	10°	0°
R / g							
$\sin\theta$							
$\lvert R - R_0 \rvert$ / g							



9. Use the graph to find the strength B of the magnetic field between the two slab-shaped magnets.

10. Apart from the assumption in Question 6, state **ONE** major source of error and suggest how to reduce this error.

END OF PAPER

香港考試及評核局
2013年高級程度會考
物理　　高級程度/高級補充程度　　卷四

考生編號：_____　　實驗檯編號：_____　　總分：20分

時間：1小時30分鐘(標有 * 的題目涉及數據量度。首60分鐘為實驗操作時間，所有量度須於此時段內完成；餘下30分鐘為整理答卷時間。)

注意：當不用錄取讀數時，開關應為斷開。

目標：透過探究載流線圈所受的磁力，以量度兩塊平板形磁鐵之間磁場的強度。

儀器：18 V 電池組 (1)，盤上固定着一個360°圓形量角器的三桿式天平 (1)，萬用電表 (1)，開關 (1)，方形探察線圈 (1)，兩塊平板形磁鐵附於鋼軛上而軛底中央黏着一指針 (1)，接線 (4)，鐵架和鉗子 (1)。

實驗：

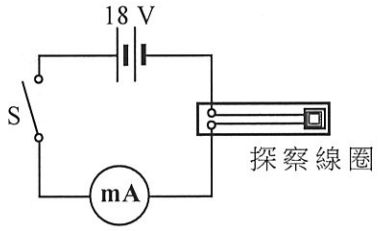
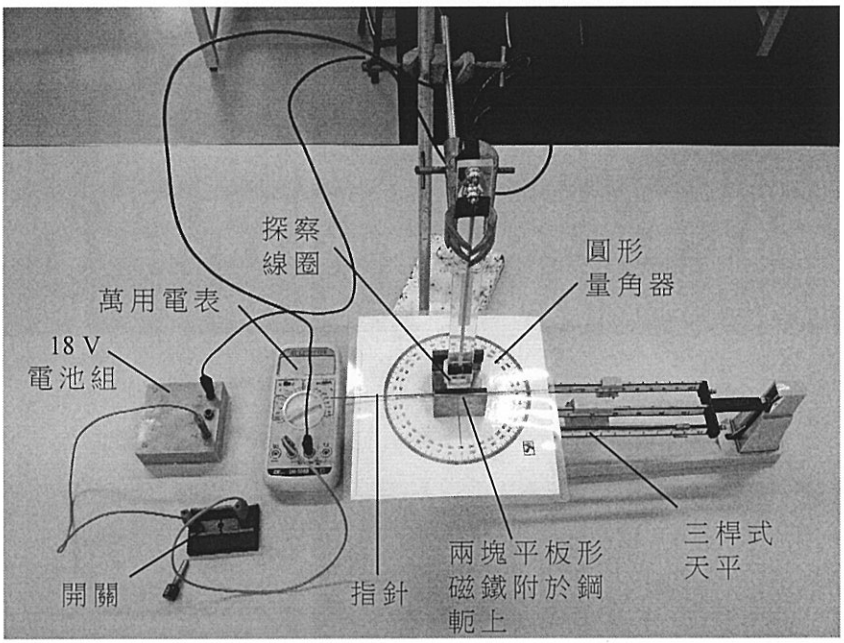
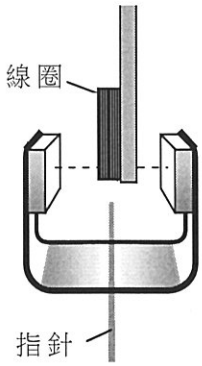


圖 1



1. 在開關 S 斷開的情況下，依圖 1 所示設置儀器，並確保做妥下列各項：
   (a) 將鋼軛放在量角器上，指針跟量角器的 90° 和 270° 刻度重疊。
   (b) 把探察線圈通過開關和萬用電表接駁到電池組，萬用電表用作毫安培計量度線圈中的電流。
   (c) 使探察線圈的手柄豎直指向上，調校探察線圈的位置直至其**底邊**如圖所示處於兩塊平板形磁鐵之間。底邊應為水平並跟磁鐵平行 (即跟磁鐵間的磁場垂直)，但**線圈及接線不應觸及任何放在天平上的東西**。

側視圖



須請主考替你檢查實驗裝置是否正確。你可用一些時間修正任何錯誤；倘若你仍無法正確設置儀器，可請主考代勞，你將因而損失 3 分。

*2. 當線圈沒有電流通過時，量度放於天平盤上物件的總質量 R_0。以克為單位記錄讀數 R_0 準確至兩個小數位以及其誤差。

R_0 = _____ ± _____ g

3. 在這個裝置中，探察線圈底邊跟磁鐵之間磁場的夾角 θ 是多少？

θ = _____ °

*4. 把開關閉合使電流 I 通過線圈。記錄電流 I 以及其誤差。

$I =$ _____ ± _____ mA

*5. 電流 I 會導致一磁力 $\boldsymbol{F}$ 作用於線圈的底邊，因此天平會失去平衡 (即天平指針會偏離零位)。現使天平回復平衡，然後量度天平的讀數 R 以及其誤差。解釋如何能以讀數 R_0 和 R 估算 $\boldsymbol{F}$ 的量值。

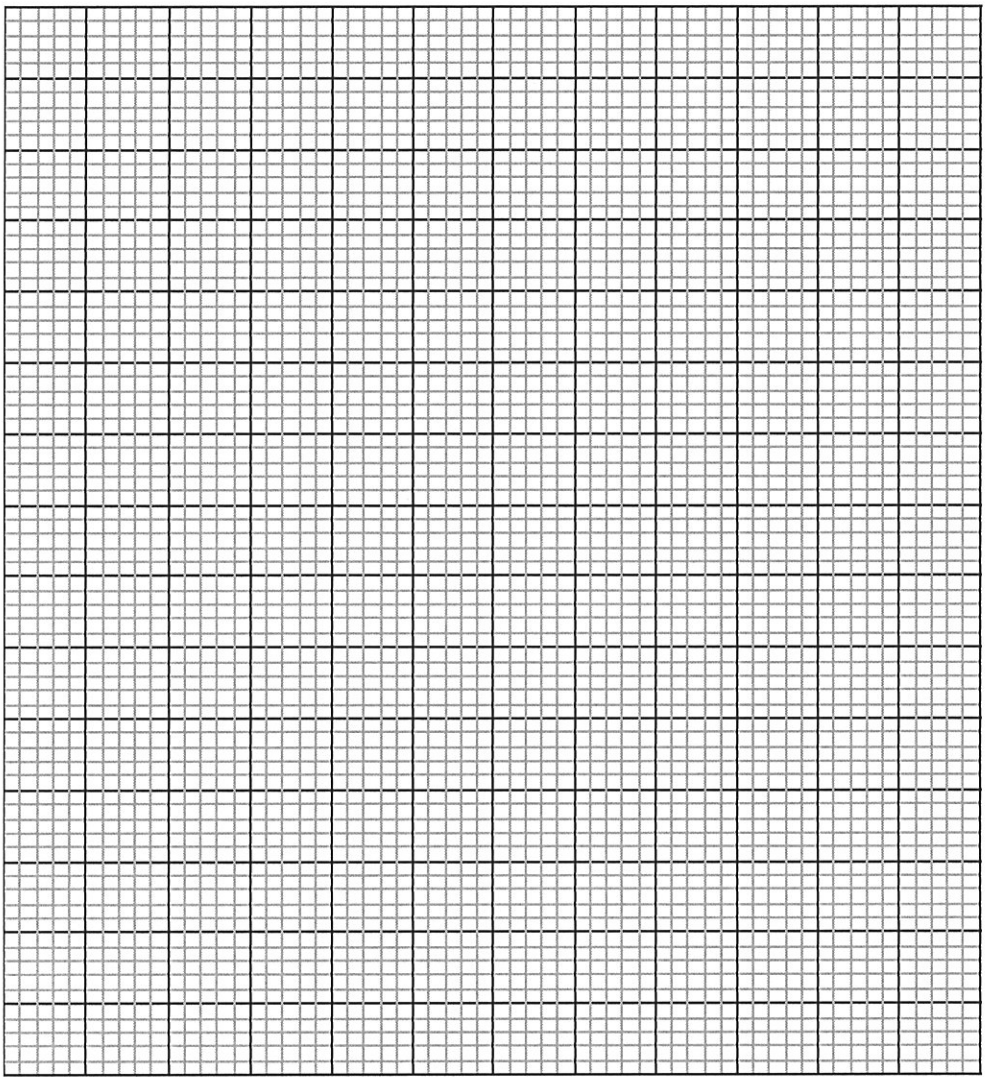
$R =$ _____ ± _____ g

6. 探察線圈的匝數 N 為 5000，而底邊長度 ℓ 為 2.0 cm；取重力加速度 g 為 9.81 m s^{-2}。利用所得數據估算兩塊平板形磁鐵之間磁場的強度 B。清楚寫出你的步驟，並指出有關估算磁場強度的假設。已知：磁場對載流導體的作用力為 $BI\ell \sin\theta$，其中 θ 為導體跟磁場的夾角。

7. 估算題 6 所得 B 值的誤差。N、ℓ 和 g 的誤差可忽略。

*8. 透過只改變鋼軛的擺放方向，重複題 4 和 5 的步驟直至得到 7 組 θ 和 R 的讀數。然後完成下表並標繪 $|R - R_0|$ 對 $\sin\theta$ 的圖線。

θ	90°	65°	45°	30°	20°	10°	0°
R / g							
$\sin\theta$							
$\lvert R - R_0 \rvert$ / g							



9. 利用圖線求兩塊平板形磁鐵之間的磁場強度 B。

10. 除題 6 的假設之外，指出誤差的<u>一個</u>主要來源並建議怎樣減少該誤差。

試卷完

Day 1 (25.5.2013) | Sessions : 1 & 2 (9:15 a.m. - 10:45 a.m./11:00 a.m. - 12:30 p.m.)

Bench spaces	1 - 18
Apparatus	1 18-V battery 1 switch (plug key) 1 digital multimeter (used as milliammeter 0 – 20 mA) 1 triple beam balance with a 360° circular protractor fixed on it 1 square search coil (5000 turns, ~ 2.0 cm × 2.0 cm) 1 steel yoke with 2 slab-shaped magnets, with a pointer attached at the middle of the bottom surface 1 set of retort stand and clamp 4 connecting wires
During session	Instruct candidates to dismantle the set-up and collect the battery at the end of the 60-minute experiment session.
Measurement after a.m. sessions	Measure the strength B of the magnetic field between the slab-shaped magnets with the set-up OR a magnetic field sensor.

Marking Scheme

Area A: Performance in Practical Work

1. The procedure for practical work is carried out safely (1 mark)
   - **Switch is open when the set-up is not attended.** **1 mark (code 1)**
2. Work is done in an organized way (2 marks)
   - ***The apparatus and connecting wires are arranged neatly so that the circuit can be checked easily.*** **1 mark (code 2)**
   - **Graph is sketched or plotted during the taking of data / before the apparatus is dismantled or answering the questions.** **1 mark (code 3)**
3. Apparatus is handled competently (2 marks)
   - ***Circuit is connected correctly without the help of examiners.** **1 mark (code 4)**
   - **Able to use the triple beam balance to take readings.** **1 mark (code 5)**
4. Instruments are used in appropriate ways to make accurate measurements (2 marks)
   - ***Bottom side of the search coil is horizontal, parallel to and in-between the slab-shaped magnets.** **1 mark (code 6)**
   - **Able to change the orientation of the steel yoke without affecting the protractor and search coil.** **1 mark (code 7)**

Area B: Reporting of Practical Work

1. Quality of the written account on the procedures and techniques (2 marks)
   - Correct explanation for Q5 [Q.5] 2 marks
2. Quality of the recording of data (3 marks)
   - Table completed with correct calculation
   - Correct graph with suitable scales and axis labels
   - Data points are correctly plotted with a suitable best-fit straight line

   } [Q.8] 3 marks
3. Quality of the presentation of results (7 marks)
   - R_0 and R correct within ± 5% of examiner's values; error = ± 0.05/0.1 g [Q.2]&[Q5] 1 mark
   - θ correct and I correct within ± 5% of examiner's values; ΔI = ± 0.01 mA [Q.3]&[Q4] 1 mark
   - Correct equation to calculate B in Q6 ($B = \frac{|R - R_0|g}{1000NIl\sin\theta}$) [accept without 1000]
   - Correct assumption related to the estimation of magnetic field

   } [Q.6] 2 marks
   - Showing correct estimation of errors in R_0, R and I due to scale uncertainties. ($\Delta R_0 = \Delta R$ = 0.05/0.1 g; ΔI = 0.01 mA)
   - Correct expression in finding ΔB ($\frac{\Delta B}{B} = \frac{\Delta R + \Delta R_0}{|R - R_0|} + \frac{\Delta I}{I}$)

   } [Q.7] 2 marks
   - B from the slope correct within ± 10% of examiner's value [Q.9] 1 mark
4. Quality of the interpretation of the results and conclusion (1 mark)
   - Able to state one major source of error and suggest a suitable method to reduce the error [Q.10] 1 mark

Sample Answer

*2. Measure the total mass R_0 of the objects on the pan of the balance when there is no current passing through the coil. Record the reading R_0 correct to 2 decimal places in grams and its error.

$R_0 =$ 133.00 ± 0.05 g

3. In this set-up, what is the angle θ between the bottom side of the search coil and the magnetic field between the magnets ?

$\theta =$ 90 °

*4. Close the switch to pass an electric current I through the search coil. Record the current I and its error.

$I =$ 10.74 ± 0.01 mA

*5. Due to the current I, there is a magnetic force $\boldsymbol{F}$ acting on the bottom side of the search coil. As a result, the triple beam loses its balance (i.e. the pointer of the balance deviates from the zero mark). Now restore the balance of the triple beam and then take the reading R of the balance and its error. Explain how the readings R_0 and R can be used to estimate the magnitude of $\boldsymbol{F}$.

$R =$ 130.30 ± 0.05 g

There is a reaction magnetic force acting on the magnets and the steel yoke according to Newton's 3rd law. (1M)

The change in reading of the balance is a measure of the magnitude of the force. (1M)

i.e. $F = \dfrac{|R - R_0|}{1000} g$ where g = gravitational acceleration

6. The number of turns N of the search coil and the length ℓ of its bottom side are 5000 and 2.0 cm respectively. Take the gravitational acceleration g as 9.81 m s^{-2}. Use the data obtained to estimate the strength B of the magnetic field between the two slab-shaped magnets. Show your steps clearly and state any assumption related to the estimation of field strength. Given: force on a current-carrying conductor in a magnetic field is $BI\ell \sin\theta$ where θ is the angle between the conductor and the magnetic field.

$F = \dfrac{|R - R_0|}{1000} g = NBIl\sin\theta$

$\Rightarrow B = \dfrac{|R - R_0| g}{1000 NIl \sin\theta} = \dfrac{|130.30 - 133.00|(9.81)}{(1000)(5000)(10.74\times10^{-3})(0.020)\sin 90°} = 0.0247\ \text{T}$

The magnetic field is uniform, horizontal and perpendicular to the bottom side of the search coil
Or the magnetic force on the upper side of the coil is neglected. (Accept other reasonable ans.)

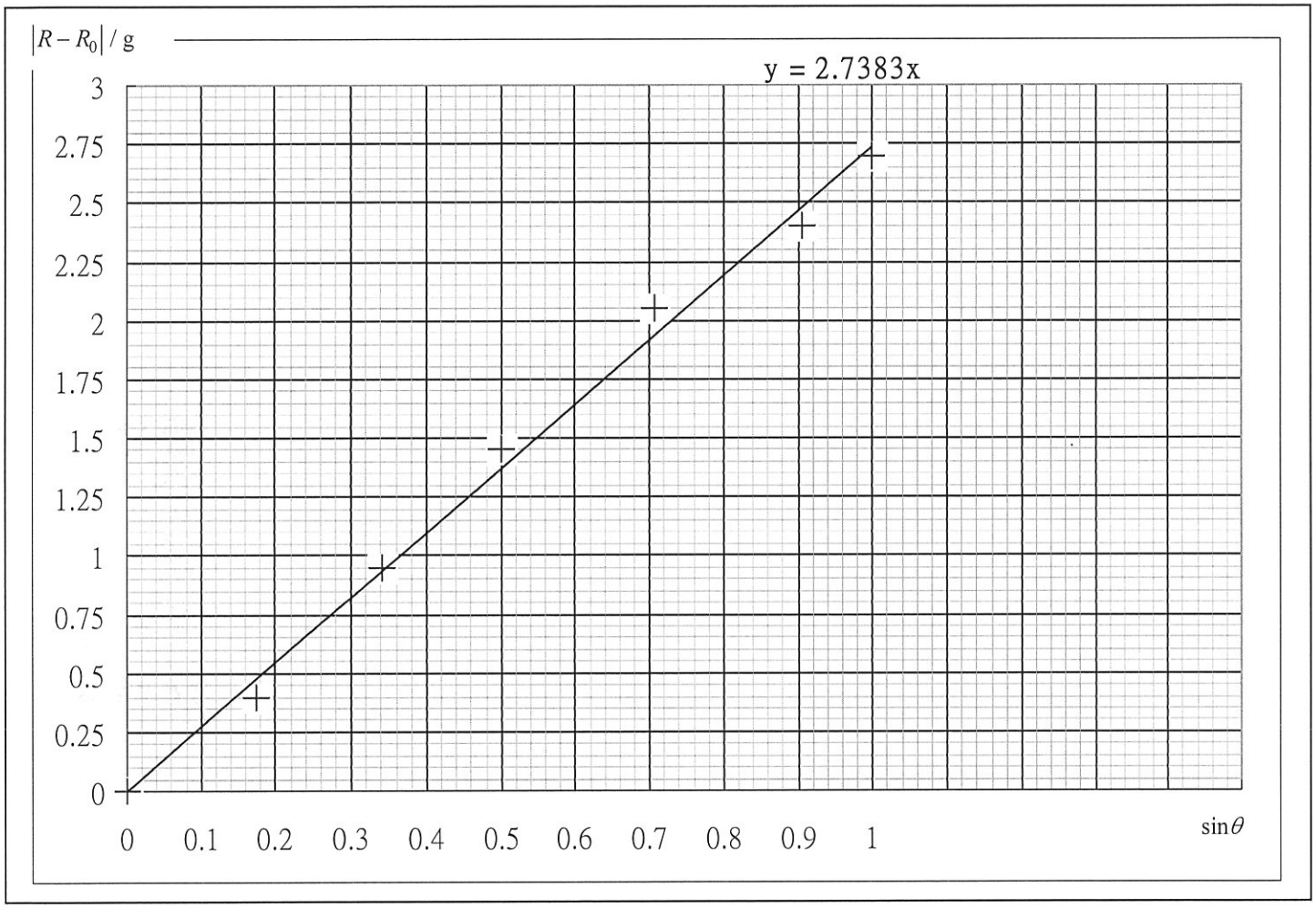
7. Estimate the error in the value of B found in question 6. Neglect the errors in N, l, θ and g.

$B = \dfrac{|R - R_0| g}{1000 NIl \sin\theta} \Rightarrow \dfrac{\Delta B}{B} = \dfrac{\Delta(R - R_0)}{|R - R_0|} + \dfrac{\Delta I}{I} = \dfrac{\Delta R + \Delta R_0}{|R - R_0|} + \dfrac{\Delta I}{I} = \dfrac{0.05 + 0.05}{|130.30 - 133.00|} + \dfrac{0.01}{10.74}$

$\Delta B = 0.94$ mT ≈ 1 mT (or $\Delta B = 1.9$ mT for taking $\Delta R = 0.1$ g)

*8. Repeat the procedures in questions 4 and 5 until you get 7 sets of readings for θ and R by changing the orientation of the steel yoke alone. Then complete the following table and plot a graph of $|R - R_0|$ against $\sin\theta$.

θ	90°	65°	45°	30°	20°	10°	0°
R / g	130.30	130.60	130.95	131.55	132.05	132.60	133.00
$\sin\theta$	1.0	0.91	0.71	0.50	0.34	0.17	0
$\lvert R - R_0\rvert$ / g	2.70	2.40	2.05	1.45	0.95	0.40	0



9. Use the graph to find the strength B of the magnetic field between the two slab-shaped magnets.

Since $F = \dfrac{|R - R_0|}{1000} g = NBIl\sin\theta \Rightarrow |R - R_0| = \dfrac{1000NBIl}{g}\sin\theta$

Hence, slope $= \dfrac{1000NBIl}{g} \Rightarrow 2.7383 = \dfrac{(1000)(5000)B(10.74\times10^{-3})(0.02)}{9.81} \Rightarrow B = 0.0250\ \text{T}$

10. Apart from the assumption in Question 6, state **ONE** major source of error and suggest how to reduce this error.

Scale uncertainty of the triple beam balance is large when compared to the weak magnetic force.

An electronic balance with less scale uncertainty should be used

Or Use stronger magnets to increase the magnetic force. (Accept other reasonable ans.)

HKDSE
Physics and CS (Physics) SBA Annual Conference

2 Nov 2013

- HKDSE SBA moderation results
- 2014 + 2015 SBA requirements
- Plagiarism handling procedures

HKDSE SBA moderation

Paper	Candidature	No. of Schools
Physics	14087	440
CS (Phy)	2946	170

Moderation	Physics	CS (Phy)
Marks slightly higher than expected (6 – 11% Difference)	25.4% (4.8% larger diff.)	24.1% (6.5% larger diff.)
Marks within the expected range (<6% Difference)	57.5%	54.1%
Marks slightly lower than expected (6 – 11% Difference)	17.1% (4.1% larger diff.)	21.8% (8.8% larger diff.)

For those higher or lower than expected, majority only deviate slightly from expected range

SBA work plan for 2013-14

- Submission requirements in 2013-14 (Ref: *School circular in late Sept*)

Month/Year	Events
2 Nov 2013	SBA annual conference
Sep 2013 – Jun 2014	S6 and S5 SBA activities to be conducted by schools
7 Jan – 28 Jan 2014	Online Submission of SBA marks, Student work samples, and 'S5 and S6 Lists of experiments' for 2014 Exam (Use experiment list template provided at HKEAA website: *SBA → DSE → Elective → Physics → Forms*)
Mar – May 2014	Moderation of S6 SBA marks by the HKEAA
May – Jun 2014	Email 'S5 Lists of experiments for 2015 Exam' and 'Blank worksheets' to District Coordinator
Jul 2014	Release of 2014 HKDSE results
Sep – Oct 2014	Provision of feedback on the outcome of the SBA moderation of 2014 HKDSE to schools

S5 + S6
(2014 Exam and after)
Requirements

	Physics		CS (Physics)
S5	1 Expt (6%)		1 Expt (5%)
S6	1 Expt (6%)	1 IS/Expt* (8%)	1 Expt (5%)

Note: Over the two years of S5 and S6, at least two marks for experiment (EXPT) and one mark for investigative study (IS) or an experiment with a detailed report (EXPT*).

On-line Mark Submission Screen --- Physics

	S5 (6%)					S6 (6%+8%)					
Student Name	E	E	E	E	E	E	E	E	E	E	IS/E*

(Note: E = EXPT, IS/E* = IS or EXPT with a detailed report)
Maximum mark per task : 20

Physics

- In SBAS, system checks:
  - At least 1 EXPT mark per student in S5
  - At least 1 EXPT mark per student in S6
  - 1 IS/EXPT mark per student in S6

On-line Mark Submission Screen --- Combined Science (Physics)

	S5 (5%)					S6 (5%)				
Student Name	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**	**E**

(Note: E = EXPT)
Maximum mark per task : 20

Combined Science (Physics)

- In SBAS, system checks:
  - At least 1 EXPT mark per student in S5
  - At least 1 EXPT mark per student in S6

Requirements for 2015 Exam (Same as 2014)

Please refer to 2015 SBA Teachers' Handbook.

HKEAA will inform schools requesting teachers to email to District Coordinators the '*List of Experiments Performed in S5*' and '*Blank worksheets for assessment*' at around May 2014.

香港考試及評核局
Hong Kong Examinations and Assessment Authority

Hong Kong Diploma of Secondary Education Examination

Revised Procedures in Handling SBA Plagiarism cases

October 2013

Background

- **No major changes** to how SBA is administered at schools
- **Minor modifications** to the procedures, with an aim to reiterate the important message to students about the proper conduct in SBA and to adopt a **unified approach** in handling plagiarism cases
- SBA continues to be an integral part of learning and teaching and its spirit upheld for the benefit of students

Preventing plagiarism in SBA

- Students to sign one declaration form (**Annex 1**) for ALL SUBJECTS at the beginning of each school year in which SBA is undertaken to declare proper conduct in SBA
- Schools to make necessary arrangement for each student to sign **ONE form for ALL SUBJECTS**. The form is available on the HKEAA website (http://www.hkeaa.edu.hk/en/sba/)
- SBA Information Leaflet – to be distributed to all S4, S5 and S6 students via schools in Nov 2013

Handling of SBA plagiarism cases

Category	Method of handling
Serious plagiarism cases (P cases): **Serious cases in which nearly the whole or the whole SBA task/assignment is plagiarised, with very little or no contribution from the student.**	**To be forwarded to the HKEAA for follow up** **- Task with "P" – zero mark** **- Down ONE Level**
Other plagiarism cases: **Less serious cases, including** **- minor infringement identified in students' SBA work, or** **- part of the student's SBA work copied from source(s) without proper acknowledgement, but the student has made some contribution to the work.**	**To be handled by schools** **- Zero mark for the task or only award the part done by the student**

Procedures in Handling P cases

- Schools should **submit a report** on the P cases identified, together with the **plagiarised work**, to the HKEAA for follow-up **AFTER** the completion of mark submission in S6
- Both the report and the plagiarised work should be submitted to the SBA Team of the HKEAA, but **NOT through the online mark submission system**
- The report should record details of the case and be submitted with relevant documents. Report template (**Annex 2**) is available on the HKEAA website (http://www.hkeaa.edu.hk/en/sba/)
- When submitting the SBA marks to the HKEAA, schools should indicate "P" in the relevant task mark for the student concerned

Procedures in Handling P cases

- These P cases will be deliberated by the HKEAA's Standing Committee
- For proven cases, a recommendation will be made to the Public Examinations Board (PEB) for their consideration
- The PEB will decide on the penalty to be imposed in accordance with the Board's guidelines on handling examination irregularities

Procedures in Handling P cases

- The levels of penalty to be imposed for proven P cases are as follows:
  - **Zero marks** will be given to the task in which serious plagiarism is proven. In addition, a penalty of **downgrade by one level** will be imposed in the subject concerned
  - For extreme cases, e.g. repeated offence of plagiarism, candidates may be subject to **disqualification from the subject(s) concerned or the whole examination**

Procedures in Handling Other Plagiarism Cases

- Other less serious cases are to be dealt with by the school
- These cases need not be reported to the HKEAA for follow-up. However, schools should keep a proper record of such cases
- In marking students' work, any proven plagiarised material should be disregarded and any marks awarded should be based on the students' own work only

Procedures in Handling Other Plagiarism Cases

- For proven cases, schools should impose appropriate penalty in accordance with the school regulations and the HKEAA guidelines, taking into consideration the seriousness of the offence. This may include:
  - Issuing a warning letter to the students (e.g. for minor offence due to negligence or committed at the initial stage of the assessment)
  - Deducting marks or awarding zero marks for the task concerned

Procedures in Handling Other Plagiarism Cases

- The following reference documents will be uploaded to the HKEAA website for schools' reference in November 2013
  1. A template for schools to record the less serious cases, which may be adapted for internal record keeping
  2. Some typical examples of suspected plagiarism cases and how they should be handled

Plagiarism Cases Identified by the HKEAA

- Suspected plagiarism cases identified during moderation of SBA marks and review of samples of student work will be handled in a consistent manner as those identified by schools
- Schools will be required to follow up on any suspected cases identified. Both P cases and other less serious cases will be handled following similar procedures as stipulated above

References and Supporting Documents (http://www.hkeaa.edu.hk/en/sba/)

- Revised Handbook for School Leaders on SBA: hardcopy to be distributed to schools in Nov 2013
- SBA Teachers' Handbooks for 2014 and 2015 exam: available on the HKEAA website
- SBA Information Leaflet: hardcopy to be distributed to schools in Nov 2013
- Student Declaration Form
- Report Template for P cases
- Template for recording less serious cases and examples of suspected plagiarism cases: available by Nov 2013

Annex 1

Hong Kong Diploma of Secondary Education Examination
Student Declaration Form for School-based Assessment (SBA)
Completed in the School Year 20__ __

Notes:

1. *This form should be signed by senior secondary students at the beginning of each school year in which SBA is undertaken. Only one form needs to be completed by each student.*
2. *The completed form should be retained by the school until the end of the public examination cycle.*

School Name: _____

Student's Name: _____

Class: _____ Class No: _____

Important Reminder to Students:

1. It is of utmost importance that academic honesty is maintained in SBA. Students are forbidden to indulge in any malpractice when completing their assessments.
2. Student can make reference to sources but must not plagiarise when completing their work. They should write in their own words and should not simply copy others' words or ideas and present them as their own. If necessary, they can quote or make reference to something written by another author in their work, as long as they ensure that these quotes or references are identified and the sources properly acknowledged.
3. Students are advised not to quote excessively in their work, as this would mean that they themselves could only make a minimal contribution to that piece of work and consequently they would be likely to get low marks from their teacher.
4. Students can make reference to the booklet *"HKDSE Information on School-based Assessment"*, (http://www.hkeaa.edu.hk/en/sba/). Some examples on how to quote and acknowledge sources properly are provided in the booklet.
5. Students will be subject to severe penalties for proven plagiarism. The HKDSE Examination Regulations stipulate that a candidate may be liable to disqualification from the subject concerned or the whole of the Examination, or suffer a mark or grade penalty for breaching the Regulations.

I certify that I have read the above Reminder and declare that:

- **All SBA tasks/assignments to be completed for all subjects in this school year will be my own work.**
- **My SBA work will not include any materials which have been copied from other sources without acknowledgement.**
- **I am responsible for ensuring that the work produced is my own and will bear the consequences of committing plagiarism or other malpractice in SBA.**

Student's signature: _____ Date: _____

Annex 2

Hong Kong Diploma of Secondary Education Examination
Plagiarism Report in School-based Assessment (SBA)

Notes:

1. *Details of serious plagiarism cases (F cases) are to be recorded in this report, which should be submitted to the HKEAA for follow-up after the completion of the mark submission in Mr, together with relevant documents.*
2. *When submitting the SBA marks to the HKEAA, schools should put "F" in the relevant mark box for the student concerned.*

School Name: _____
Student's Name: _____ Candidate No.: _____
Class: _____ Class No.: _____
Subject: _____

Case Summary

	Details / Remarks
Task/assignment involved	
Date of completion of the task/assignment	
Irregularities identified	*(Please tick as appropriate)* ☐ Nearly the whole task/assignment is plagiarised ☐ The whole task/assignment is plagiarised ☐ Others (please specify): _____
Documentation	The following documents are submitted as evidence: 1. The SBA task/assignment 2. The student's work, with the plagiarised part(s) highlighted 3. The source material(s) from which the unacknowledged work is copied 4. Others *(please specify)*: _____
Follow-up actions taken	Student was interviewed on _____ (Date) and informed about the submission of this report to the HKEAA. Others *(please specify)*: _____

Contact Person

Name: _____ Post: _____
Telephone No.: _____

_____ _____
Signature of Subject Teacher Signature of Principal

School seal

_____ _____
Name of Subject Teacher Name of Principal

_____
Date

Thank you

Physics
&
C S (Physics)

SBA marks - Online Submission

(2 Nov 2013)

School-based Assessment System (SBAS)

S5 + S6 Submissions (2014 Exam)

What to submit

- S5 and S6 Marks
- Student Work samples
- S5 and S6 Experiment Lists

When to submit

- **7 Jan – 28 Jan 2014**
- SBA Marks, Student Work and Teacher Document (Expt. Lists) share the same submission period.
- Please submit SBA marks to principal for endorsement in advance to allow sufficient time for completion of other submissions.

Points to note before submission

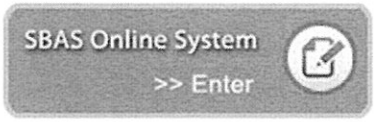
- **Formal approval from HKEAA** is required for exemption of SBA marks. If a student has fulfilled the minimum requirements, exemption is not required. No need to enter any symbol in the respective mark cell(s).

Submission Procedures

香港考試及評核局
Hong Kong
Examinations and
Assessment Authority

Hong Kong Diploma of Secondary Education
School-based Assessment System (SBAS)
Operation Guide

October 2013



- The work flow remains unchanged.
- The online system is more user-friendly.
- With accurate candidates' information, mark data more secure
  (see the slides for details)

Overview of the SBA submission process

Overview of the SBA submission process

School Administrator	Subject Panel (1st stage)	Subject Teacher	Subject Panel (2nd stage)	Principal	Subject Panel (Last stage)
• Create login accounts for teachers and panels • Indicate the SBA subjects being offered in this school year • Assign SBA subjects to panels and teachers	• Create teaching groups • Assign students to teaching groups • Assign teachers to teaching groups	• Input SBA marks (online input or batch input using the mark template) • Endorse SBA marks of responsible teaching group(s) • Submit SBA Marks to Panel	• Endorse SBA marks submitted by all teachers of a subject • If necessary, return to teacher for amendments • Submit SBA Marks to Principal	• Endorse SBA marks for all subjects • If necessary, return to panel to handle • Submit SBA Marks to HKEAA	• Upload Student Work of all selected students • Upload Teacher Document if required

Subject Panel (1st stage)

Subject Panel

Assign Teaching Group
- Assign students to Teaching Groups
- Assign teachers to Teaching Groups

Teachers input marks

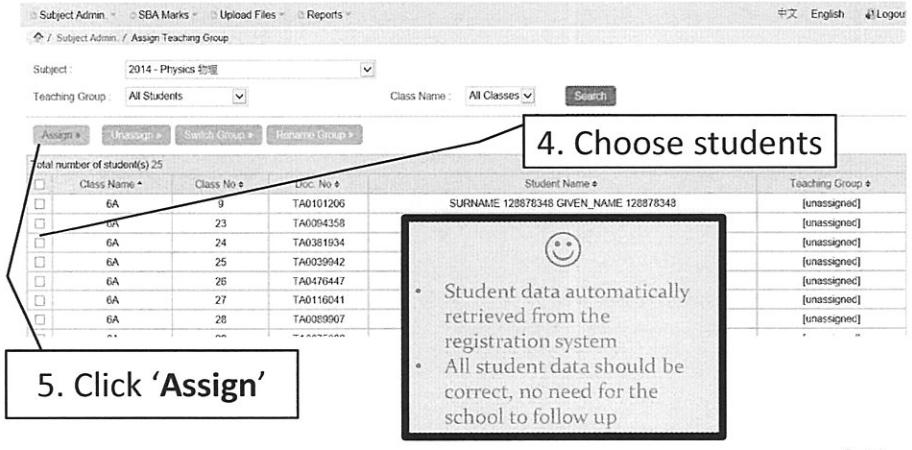
Submit to principal
- Review all the SBA marks of the subject, and submit to Principal
- If necessary, return the marks to teacher for amendment

Upload files
- Upload Student Work of the selected students
- Upload Teacher Document (if applicable)

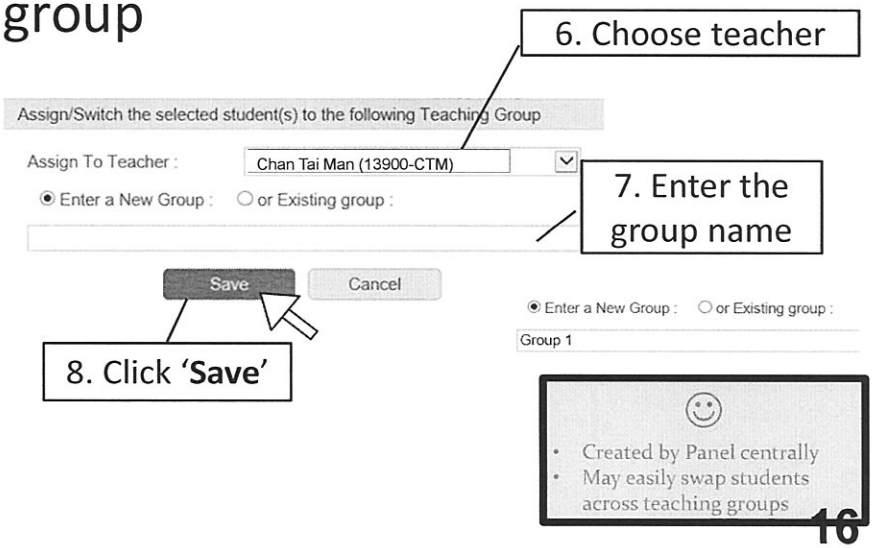
Subject Panel – assign teaching group

Subject Panel – assign teaching group

Subject Panel – assign teaching group

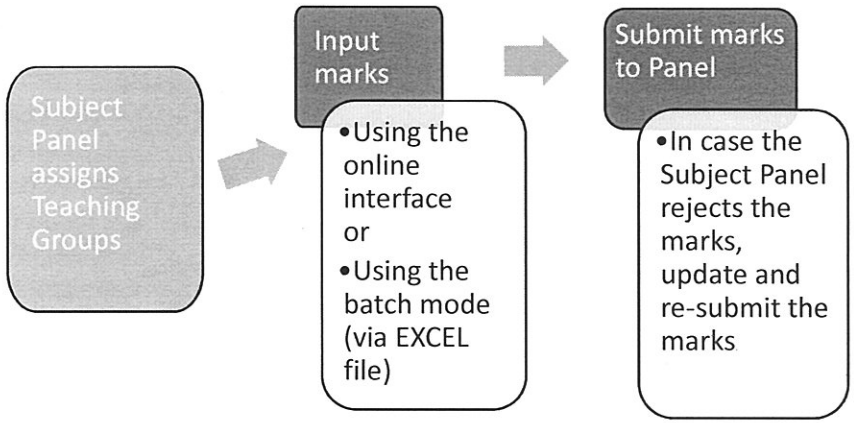


Subject Panel – assign teaching group

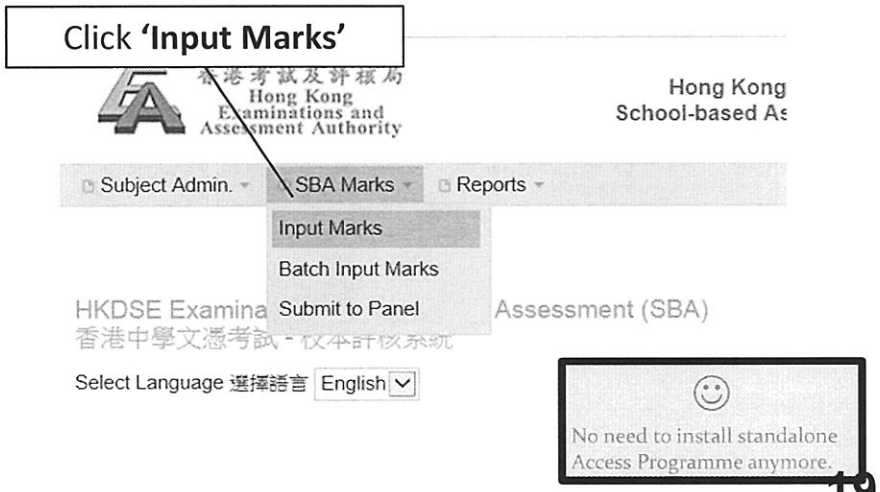


Subject Teacher

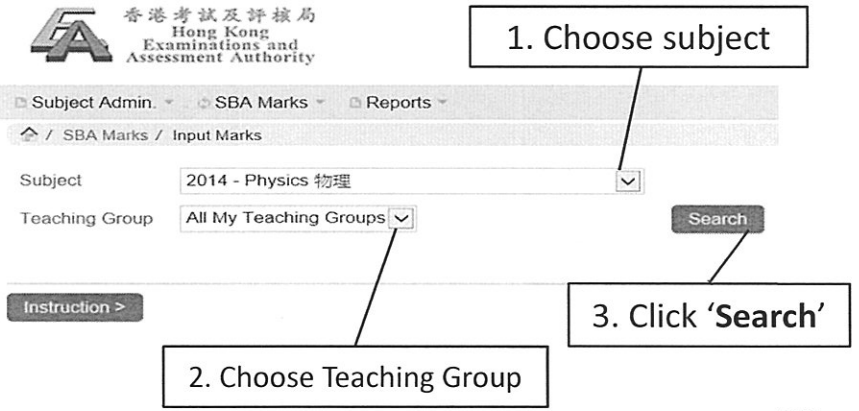
Subject Teacher



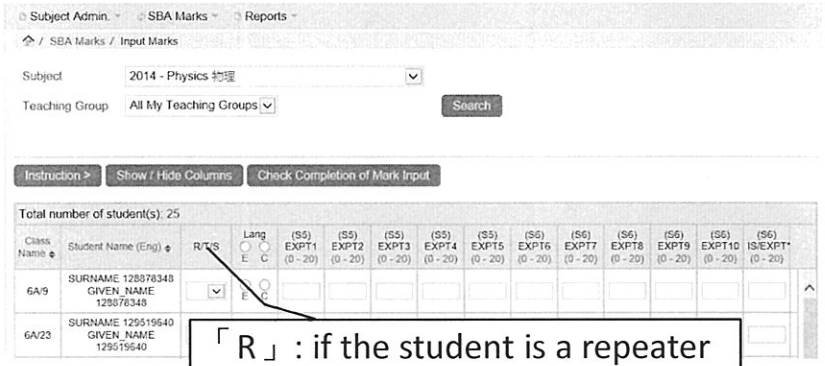
Subject Teacher – input marks



Subject Teacher – input marks

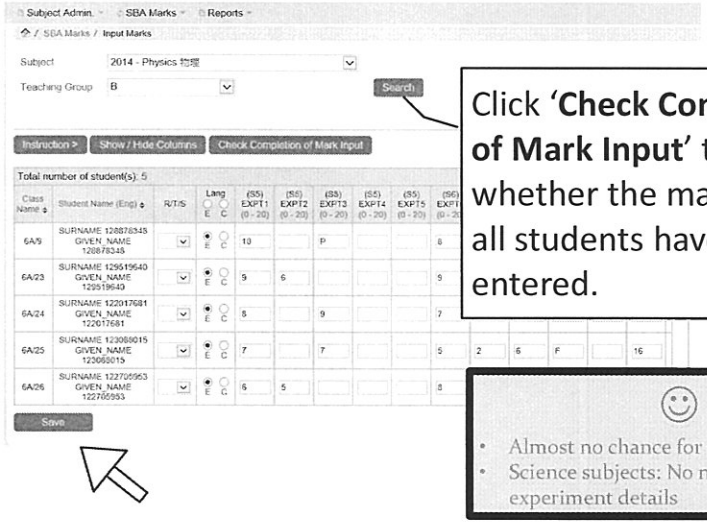


Subject Teacher – input marks



「R」: if the student is a repeater
「T/S」: if the student is a transfer student/switched course

Subject Teacher – input marks

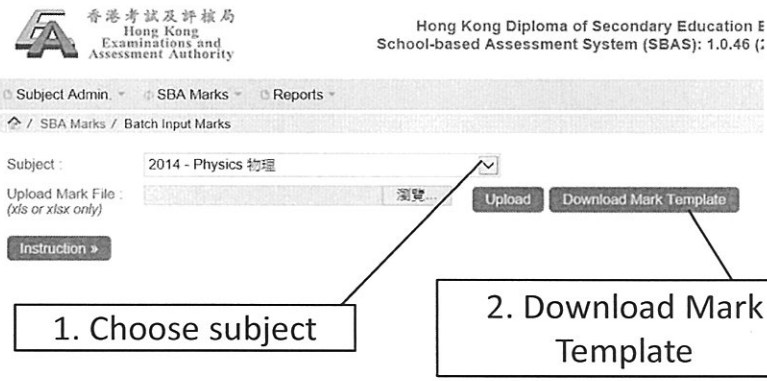


Click '**Check Completion of Mark Input**' to check whether the marks for all students have been entered.

- Almost no chance for missing candidate
- Science subjects: No need to enter experiment details

Subject Teacher – batch input

Subject Teacher – batch input



1. Choose subject

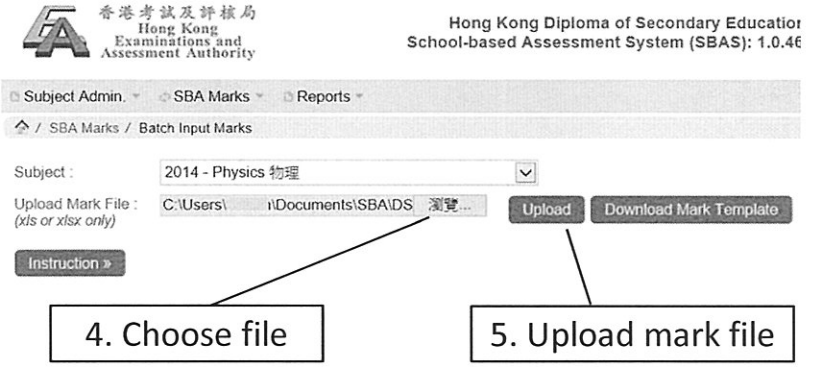
2. Download Mark Template

Subject Teacher – batch input

3.Input marks in the EXCEL file

25

Subject Teacher – batch input



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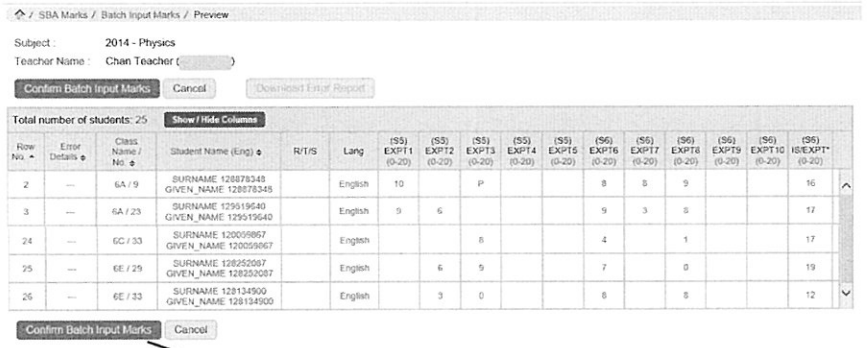
Subject Teacher – batch input



27

Submit marks to Panel

28

Submit marks to Panel

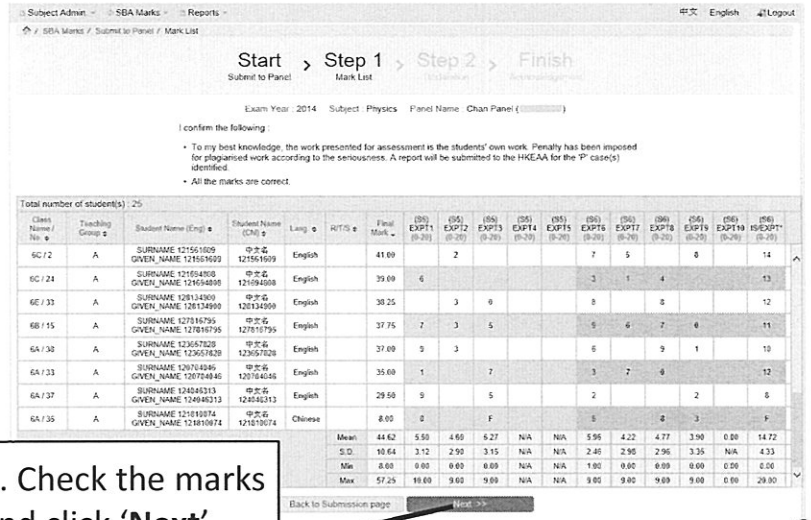
1.Choose subject

2.Click '**Search**'

- No need to import/export data.
- Increased data security.

3.Click '**Submit to Panel**'

Submit marks to Panel



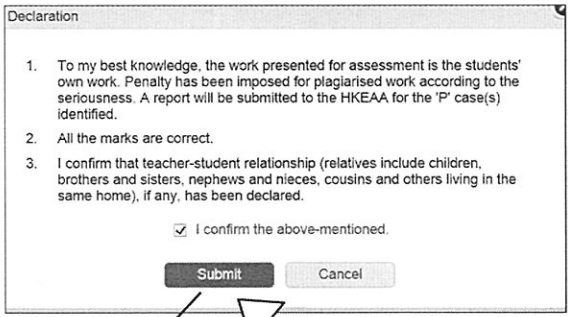
4. Check the marks and click '**Next**'

Submit marks to Panel

Input teacher-student relationship, if any

Click '**Finish**'

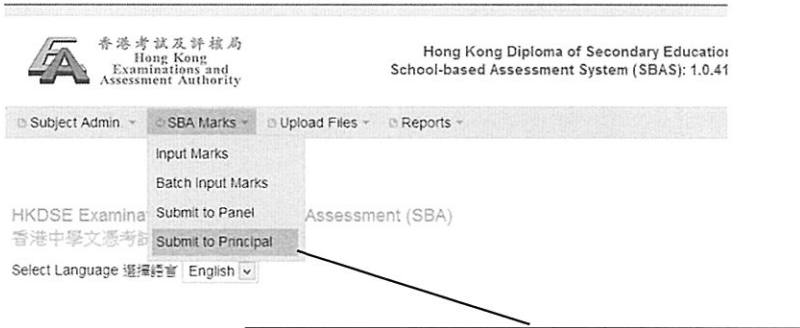
Submit marks to Panel



Click '**Submit**'

Subject Panel
(2nd stage)

Subject Panel – submit to principal



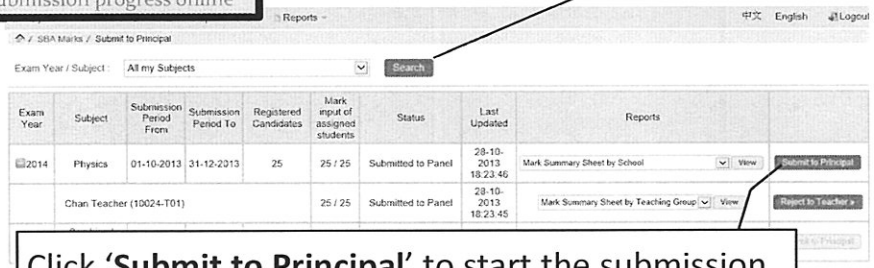
Mouse over the SBA Marks menu and then click '**Submit to Principal**'

- No need to import/export data.
- Increased data security.

Subject Panel – submit to principal

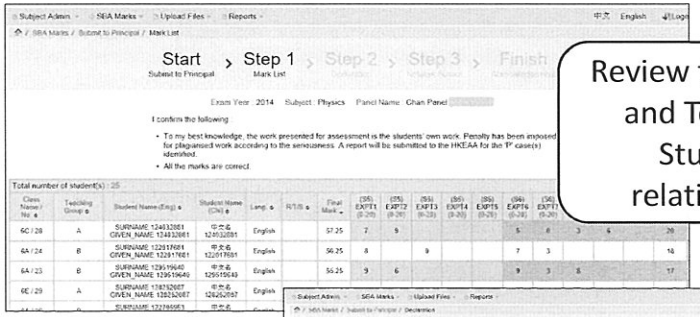
Panel can monitor the submission progress online

Select subject and click '**Search**'



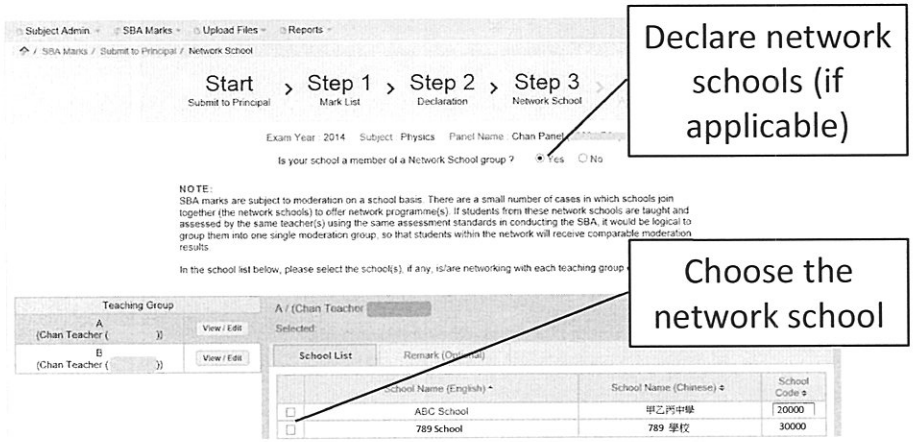
Click '**Submit to Principal**' to start the submission. If necessary, click '**Reject to Teacher**' to return the marks to teacher for amendment.

Subject Panel – submit to principal



Review the marks and Teacher-Student relationship

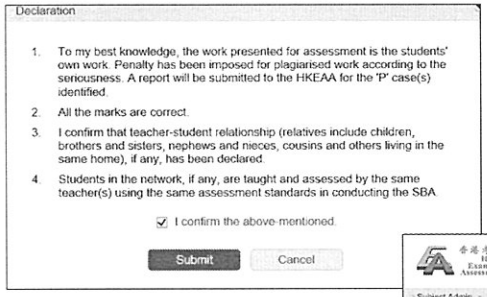
Subject Panel – submit to principal



Declare network schools (if applicable)

Choose the network school

Subject Panel – submit to principal



Go through the declaration statements and click '**Submit**'

Principal

Principal

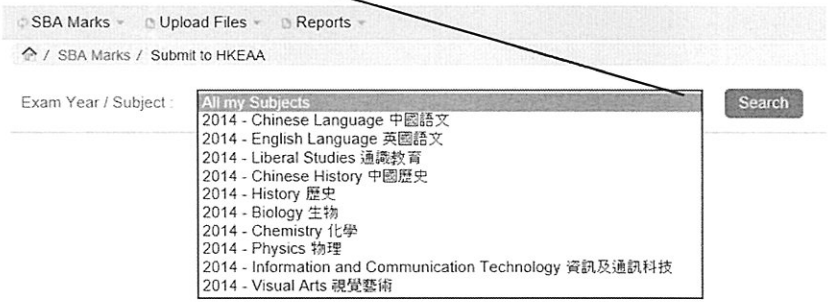
- Review SBA marks of all subjects and submit to the HKEAA
- If necessary, return the marks to the panel to handle

Principal – submit to HKEAA

Click '**Submit to HKEAA**'

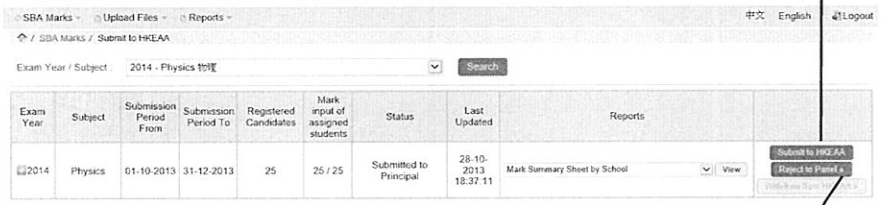
Principal – submit to HKEAA

Choose subject and click '**Search**'



Principal – submit to HKEAA

Click '**Submit to HKEAA**' to start the submission

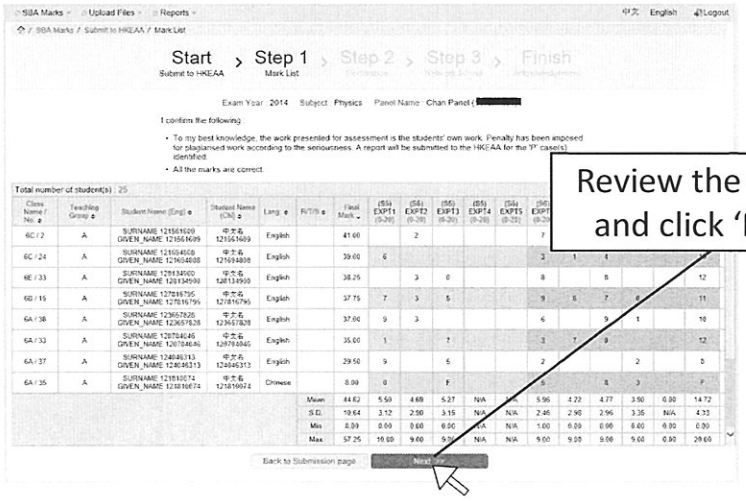


If necessary, click '**Reject to Panel**' to return the marks to the panel for following up.

Principal can monitor the submission progress online

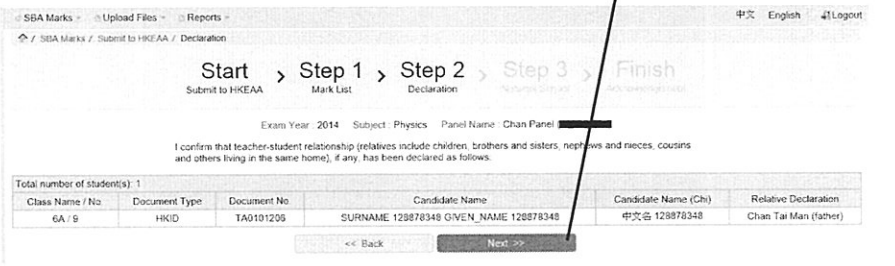
Principal – submit to HKEAA

Review the marks and click '**Next**'



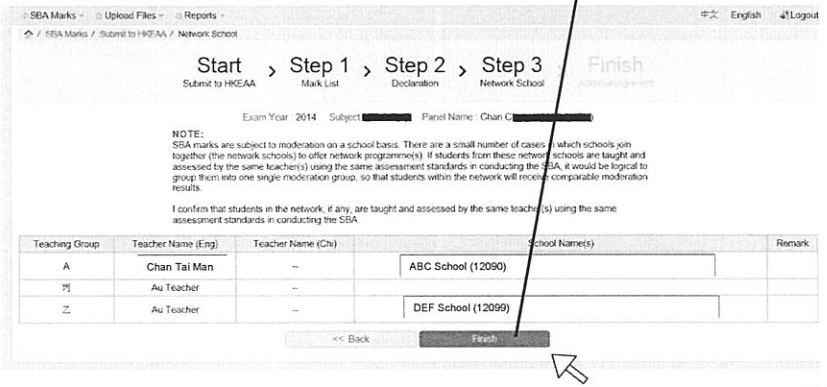
Principal – submit to HKEAA

Review the Teacher-Student relationship and click '**Next**'

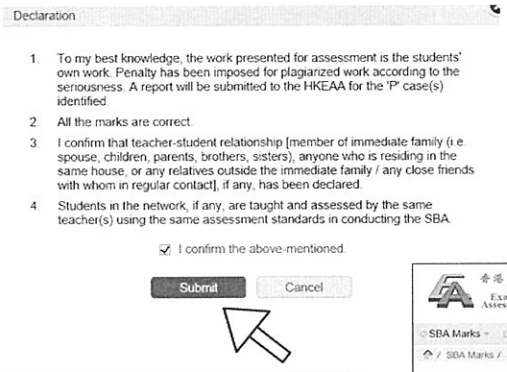


Principal – submit to HKEAA

Review the network school declaration and click '**Finish**'



Principal – submit to HKEAA



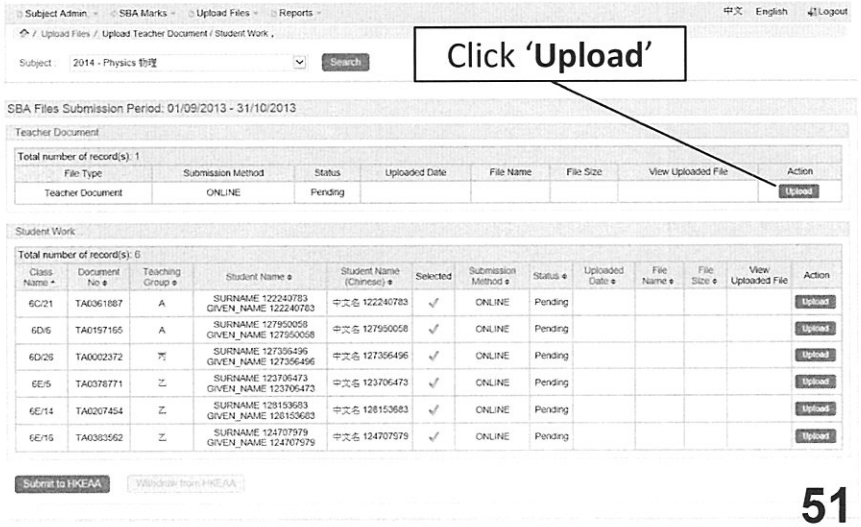
Go through the declaration statements and click '**Submit**'

Subject Panel (Last stage)

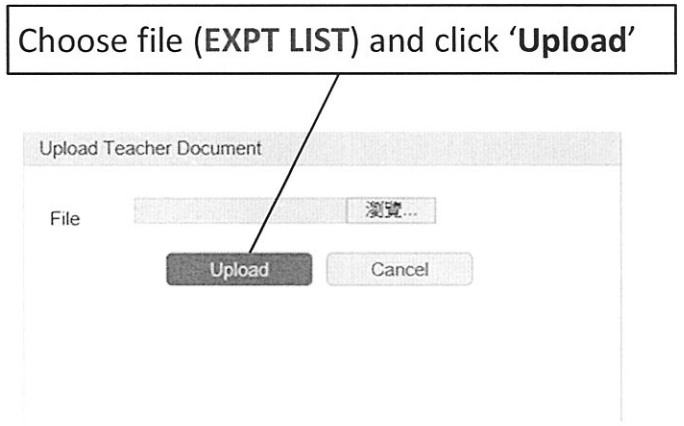
Subject Panel – upload files

Subject Panel – upload files

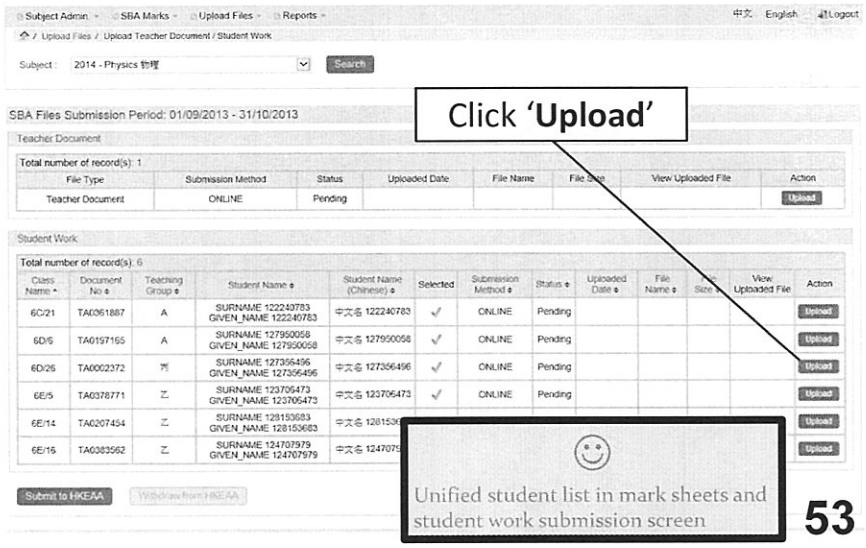
Subject Panel – upload **EXPT LIST**



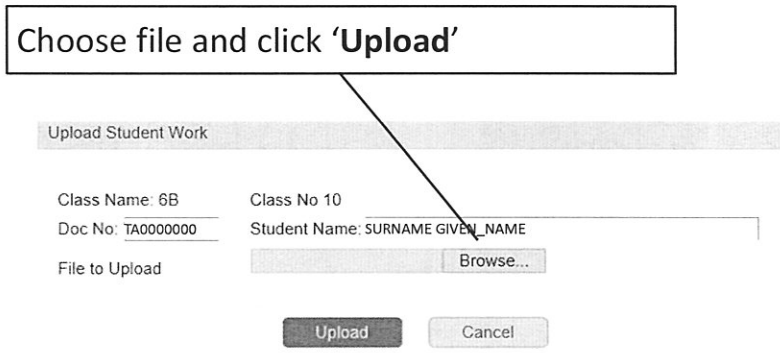
Subject Panel – upload files



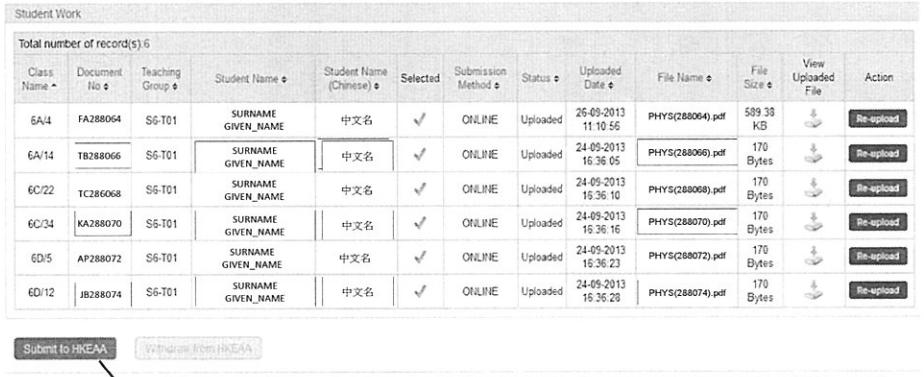
Subject Panel – upload files



Subject Panel – upload files



Subject Panel – upload files



Reminders

- Only student work with marks submitted to HKEAA are required.
- The work for each student should be zipped to one single file if the work contains more than one file.

Reminders

- If need scanning, advise students to use A4 paper to do their homework.
- If one or two reports were lost, mark in the first page of the student work file, e.g. Chan Tai Man has lost report #2 and #5.
- Attach lab. manual/guidelines in the student work file for the convenience of checking by District Coordinators.

Reminders

- Suggested file naming convention:

[Subject Abbreviation] [(6-digit Student Document Number)].[File extension]

e.g. PHYS(123456).zip PHYS(362880).pdf
CSPHY(246800).doc

Student Document Number is the beginning 6 digits of the identity document of a student.

Reminders

- The system only accepts file formats of **zip, pdf, txt, doc, docx, rtf, ppt, pptx, xls, xlsx, csv, mp4, mp3, mpg, wmv, avi, jpg or tif**.
- The file size limit for each student's work file is 10MB.

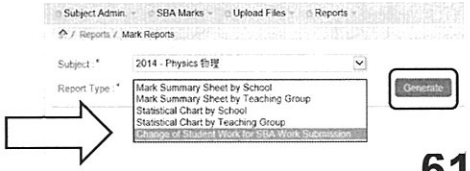
Reminders

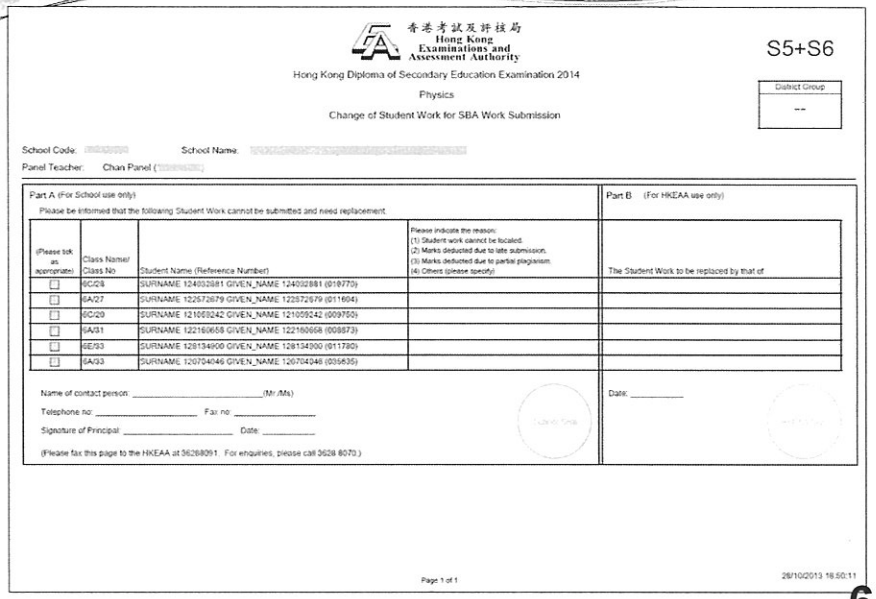
- Teacher Document for **Physics, means S5+S6 List of Experiments performed.**
- **Please make use of the template provided at HKEAA website:**

SBA → DSE → Elective → Physics → Forms

Request for a change of student(s) for work submission

- If the work of any chosen student cannot be located, or involves any irregularities (such as mark penalty being imposed due to partial plagiarism or late submission), the Subject Panel should contact the SBA Team at 3628 8068.
- Subject Panel should download the '**Change of Student Work for SBA Work Submission**' form from '**Mark Reports**' under '**Reports**' menu.





香港考試及評核局
Hong Kong Examinations and Assessment Authority

S5+S6

Hong Kong Diploma of Secondary Education Examination 2014

Physics

Change of Student Work for SBA Work Submission

District Group: --

School Code: [redacted] School Name: [redacted]

Panel Teacher: Chan Panel ([redacted])

Part A (For School use only)

Please be informed that the following Student Work cannot be submitted and need replacement.

(Please tick as appropriate)	Class Name/ Class No	Student Name (Reference Number)	Please indicate the reason: (1) Student work cannot be located. (2) Marks deducted due to late submission. (3) Marks deducted due to partial plagiarism. (4) Others (please specify)	Part B (For HKEAA use only) The Student Work to be replaced by that of
☐	6C/26	SURNAME 124032881 GIVEN_NAME 124032881 (019770)		
☐	6A/27	SURNAME 122672679 GIVEN_NAME 122672679 (011604)		
☐	6C/20	SURNAME 121059242 GIVEN_NAME 121059242 (009750)		
☐	6A/31	SURNAME 122160658 GIVEN_NAME 122160658 (008873)		
☐	6E/33	SURNAME 128134900 GIVEN_NAME 128134900 (011780)		
☐	6A/33	SURNAME 120704046 GIVEN_NAME 120704046 (035635)		

Name of contact person: _____ (Mr./Ms)

Telephone no: _____ Fax no: _____

Signature of Principal: _____ Date: _____

(Please fax this page to the HKEAA at 36288091. For enquiries, please call 3628 8070.)

Date: _____

Page 1 of 1

26/10/2013 16:50:11

Request for a change of student(s) for work submission

- Complete the section for the school and fax the form to 3628 8091.
- After confirming the arrangement, the HKEAA will fax the amended form to the school for school's record.

Support Measures

User Manual

- Available on HKEAA website by November 2013 (https://www.hkdse.hkeaa.edu.hk)


USER MANUAL

FOR

SCHOOL-BASED ASSESSMENT (SBA)
OF HONG KONG DIPLOMA OF SECONDARY EDUCATION
(HKDSE) EXAMINATION

Enquiry Hotlines

- General Issues:
  - 3628-8860 (and press 1, 7, 1)
- Subject Matters:
  - 3628-8064
  - 3628-8070

Thank you

HKDSE Physics/ CS(Phy) SBA

List of Experiments

Examination year: _____ (e.g. 2014)

Please record ALL the experiments done in S5 and S6 for this examination cohort. You may ADAPT the form to suit your need.

School name: _____ SBA Group no.: _____

Subject Panel's name: _____ Tel. no.: _____ Email: _____

Experiment Title	Subject*		Year*		Type*		Submit Marks^
	Phy	CS	S5	S6	EXPT	IS/EXPT*	

* Please tick the appropriate box.

^ You may leave this column blank when emailing this form to the District Coordinator in S5.
When uploading this form to the SBA online system in S6, please tick the experiments selected for mark submission.

(Draft as of 28 Oct 2013)

Detailed Experiment Report - Format

The following table serves to illustrate the scope of a detailed report comparing to a formal report/full report:

Title		detailed report	formal report/full report
1.	**Problem statement**	√	√
2.	**Experimental hypothesis / objectives**	√ **(May be given in the lab manual or implied from the problem statement)**	√
3.	**Experimental design**		
(i)	**Apparatus**	√	√
(ii)	**Description of design**		
	- **Theory**	√ / X **(optional)**	√
	- **Procedures**	X **(Covered in the lab manual)**	√
(iii)	**Measurement**	√	√
4.	**Data evaluation**	√	√
5.	**Error analysis**	√ / X **(optional)**	√
6.	**Summary, conclusions and possible improvements**	√	√

Note: Items 1, 2 and 3(i)(ii) are often partly covered in the laboratory manual provided by teachers, students are only required to complete the remaining items such that the laboratory manual together with the student's work will combine to give a detailed report.

Physics - Detailed Laboratory Report (Sample)

(Part A - Complied by teacher)

Title: To determine the internal resistance of a cell

Aim: Using a voltmeter and an ammeter to determine the internal resistance of a cell from a V - I graph.

Apparatus: dry cell, ammeter, multimeter (set to the range 250 mA), voltmeter, rheostat, resistance box.

Theory:

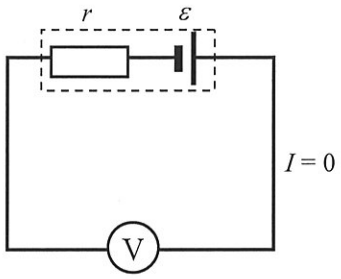


Figure 1

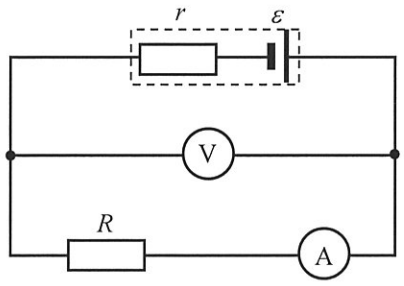


Figure 2

A dry cell stores chemical energy. When a dry cell is connected in a circuit, the dry cell releases the chemical energy as the electrical potential energy. The electromotive force (e.m.f.) E of a cell shows how much electrical energy would be converted from the cell per unit charge passing through it.

The electromotive force can be measured by a voltmeter which is connected across it directly as shown in Figure 1. When the cell is connected to a resistor R (shown in Figure 2), a current I, measured by the ammeter, would pass through it. If the cell has internal resistance r, the energy per unit charge that it transfers externally will be less than the electromotive force, because some energy will be consumed by the internal resistance. The amount of energy dissipated within the cell depends on the current and the internal resistance, and so voltage drop is equal to Ir.

Taking stock of the energy changes in the complete circuit including the cell, based on conservation of energy, we can say

Energy supplied per coulomb by cell

= energy changed per coulomb by external circuit + energy wasted per coulomb by internal resistance of cell

Or, from the definitions of e.m.f. and p.d.,

e.m.f. = p.d. across R + p.d. across r (where R: external resistance, r: internal resistance)

In symbols, $E = V_e + V_i$

e.m.f. useful volts lost volts

where V_i is the p.d. across the internal resistance of the cell, a quantity that cannot be measured directly but obtained only by subtracting V_e from E. From the equation $E = V_e + V_i$, we see that the sum of the p.d.s across all the resistance in a circuit (external and internal) equals the e.m.f. Since $V_e = IR$ and $V_i = Ir$, the previous equation can be rewritten:

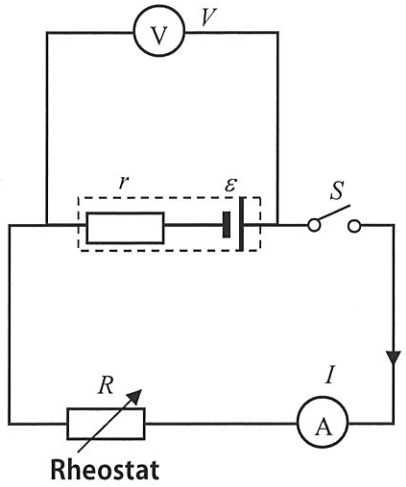
$$E = IR + Ir$$

i.e.

$$E = I(R+r)$$

Method:

Measuring e.m.f. and internal resistance of a cell from V - I graph



(Figure 3)

Procedure (<u>format 1 - less structured approach</u>):

1. **Set up the apparatus as shown in Figure 3.**
2. **Connect the circuit such that the dry cell is in series with a rheostat and an ammeter.**
3. **Measure the external voltage across terminals of the cell by a voltmeter.**
4. **Adjust the resistance *R* of the rheostat to obtain 8 pairs of ammeter reading *I* and voltmeter reading *V* over the widest possible range of *R*.**

Procedure (<u>format 2 - structured approach</u>):

1. **Connect the circuit as shown in Figure 3.**
2. **Keep the switch open. Take the reading of the voltmeter. This is the initial electromotive force (e.m.f.) of the cell.**
3. **Set the rheostat to zero. Close the switch and take the ammeter and voltmeter readings. Open the switch once the readings are taken.**
4. **Increase the resistance of the rheostat. Close the switch and adjust the rheostat until the current is roughly 0.1 A below the value in step (3). Take the ammeter and voltmeter readings. Remember to open the switch once the readings are taken.**
5. **Repeat step (4) by decreasing the current in steps of 0.1 A. Plot a graph of the voltage *V* against the current *I*.**

Results (Part B- Compiled by individual student)

Measurement and data evaluation:

1.

Voltage V/V	2.0	2.1	2.3	2.4	2.5	2.6	2.7	2.8
Current I/A	0.083	0.060	0.050	0.040	0.030	0.023	0.015	0.005

2. Based on the circuit shown in Figure 3, the terminal voltage V across the cell is related to e.m.f. E of the cell, the internal resistance r of the cell and the current I by the following equation:

   $V = E - Ir$

   Or $V = -rI + E$ (This is a straight line equation of the form: $y = mx + c$)

3. The terminal voltage V against current I was plotted on a graph paper (Graph 1).
4. The slope of the graph was measured to give the internal resistance r and the Y-intercept to give the e.m.f. E of the cell.
5. Slope of the graph = -11.1 V A^{-1}

   Y-intercept = 2.85 V
6. The internal resistance of the cell = 11.1 Ω

   The e.m.f. E of the cell = 2.85 V

Discussion:

I. Source of error:

1. The wire used to connect the circuit contains resistance, so thicker wire should be used to reduce the resistance, so a more accurate result will be obtained.
2. The result of the experiment would be affected by the condition of the surrounding. For example, if the temperature increases, the resistance of the wire will decrease.
3. The readings of the voltmeter, ammeter and multimeter were not read by us vertically, so the readings were not so accurate.

II. Precautions:

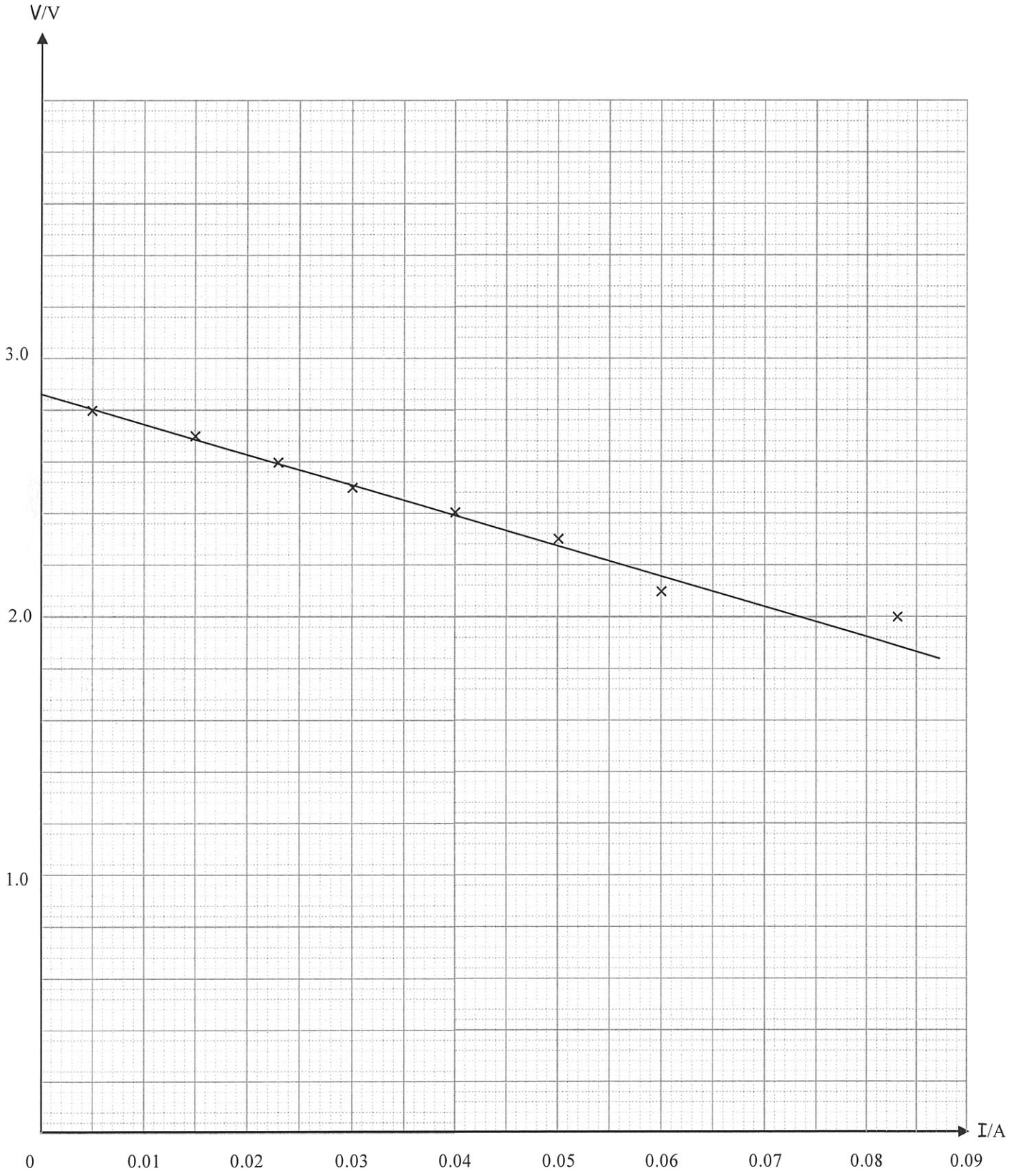
1. The multimeter should be set-zero before it is used as an ohmmeter. Set-zero is also necessary when the scale in the ohmmeter is changed.
2. The resistance box may have poor resistance because of rusting at the contact surfaces. Use sand-paper to polish all the contacting points before use.
3. Note the polarities of the meters and the cell. Avoid causing the pointer to deflect in the wrong direction.
4. Set the rheostat to the largest value before the experiment starts.
5. Never close the switch while the connection is being made.
6. To avoid unnecessary heating, open the switch after each reading. Also, this can minimize the change of e.m.f. E and so to obtain a more accurate result.

Conclusion:

In the experiment, the voltmeter-ammeter method has been used to find the e.m.f. and internal resistance of a cell. Based on the result of experiment, the internal resistance of the cell was 11.1 Ω and its e.m.f. E was 2.85 V.

Method (V – I graph):

Graph (1): Relationship between Terminal Voltage and Current

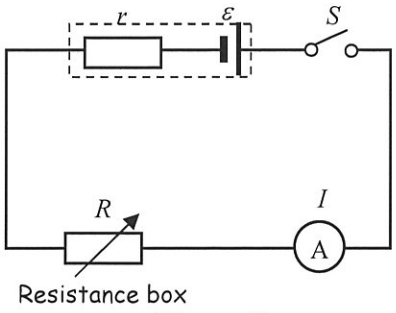


Alternative Method:

(Complied by teacher)

Title: **To determine the internal resistance of a cell**

Aim: **Using a voltmeter and an ammeter to determine the internal resistance of a cell from a R - 1/I graph.**



(Figure 4)

Procedure:

1. **Connect the circuit as shown in Figure 4 in which the resistance box and the ammeter are in series.**
2. **Set the resistance box to an appropriate large value. Record the values of /and *R*.**
3. **Reduce resistance *R* of the resistance box. Repeat the measurements of /and *R* to obtain 8 pairs of data.**

Results (Compiled by individual student)

Measurement and data evaluation:

1.

Resistance R/Ω	34	30	27	25	22	19	17	15
Current I/A	0.060	0.045	0.067	0.073	0.081	0.087	0.091	0.097
$1/I$ / A^{-1}	16.8	15.5	15.0	13.7	12.4	11.5	11.0	10.3

2. Based on the circuit shown in Figure 4, the current I is related to e.m.f. E of the cell, the internal resistance r of the cell and the external resistance R by the following equation:

   $I = (E - Ir) / R$

   Or $R = E(1/I) - r$ (This is a straight line equation of the form: $y = mx + c$)

3. The resistance R against the reciprocal of current 1/I was plotted on a graph paper (Graph 2).
4. The slope of the graph was measured to give the e.m.f. E of the cell and the Y-intercept to give the internal resistance r.
4. Slope of the graph = 2.92 Ω A^{-1}

   Y-intercept = -15.0 Ω
5. The e.m.f. E of the cell = 2.92 V

   The internal resistance of the cell = 15.0 Ω

Discussion:

I. Source of error:

1. The wire used to connect the circuit contains resistance, so thicker wire should be used to reduce the resistance, so a more accurate result will be obtained.
2. The result of the experiment would be affected by the condition of the surrounding. For example, if the temperature increases, the resistance of the wire will decrease.
3. The readings of the voltmeter, ammeter and multimeter were not read by us vertically, so the readings were not so accurate.

II. Precautions:

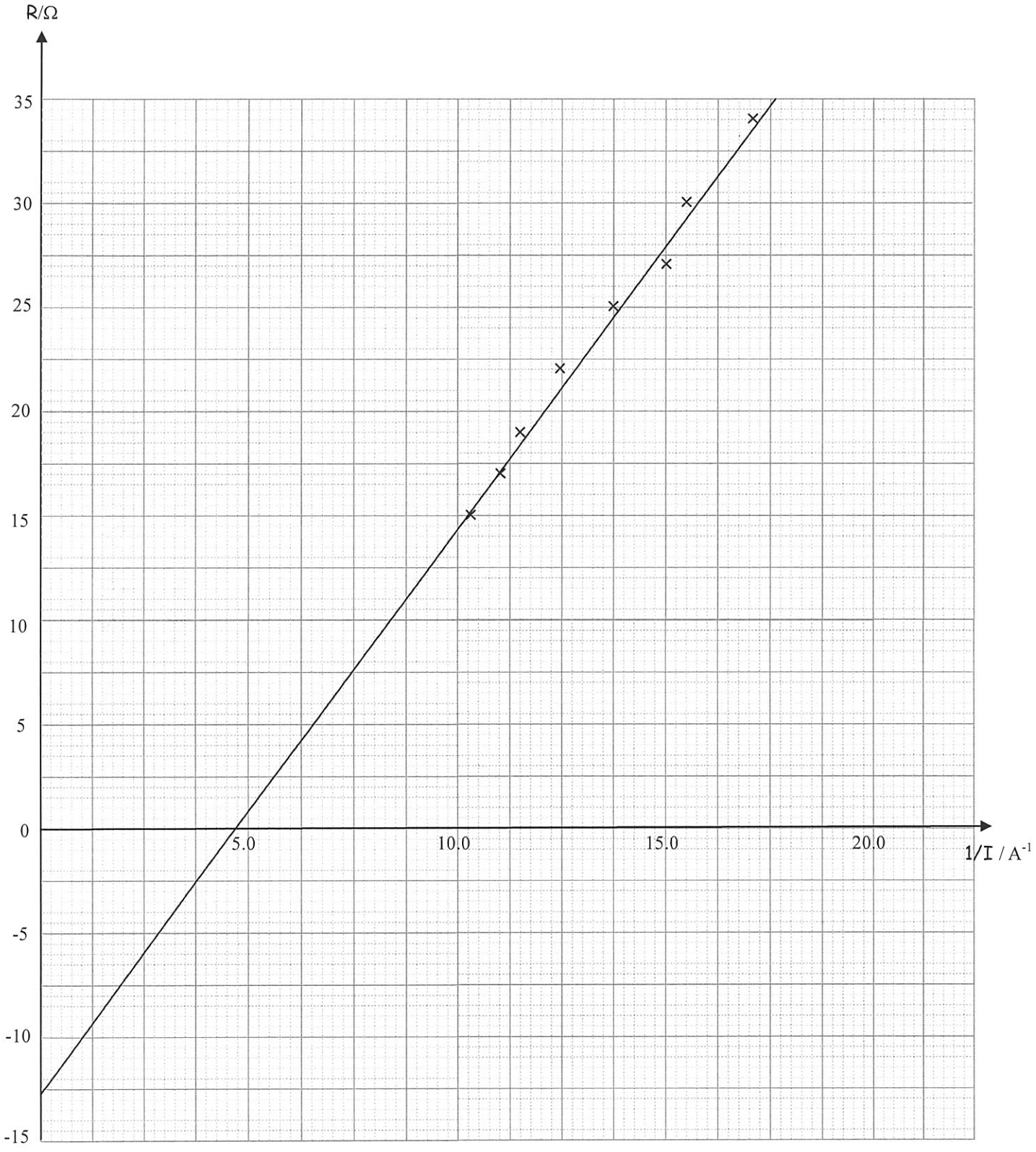
1. The multimeter should be set-zero before it is used as an ohmmeter. Set-zero is also necessary when the scale in the ohmmeter is changed.
2. The resistance box may have poor resistance because of rusting at the contact surfaces. Use sand-paper to polish all the contacting points before use.
3. Note the polarities of the meters and the cell. Avoid causing the pointer to deflect in the wrong direction.
4. Set the rheostat to the largest value before the experiment starts.
5. Never close the switch while the connection is being made.
6. To avoid unnecessary heating, open the switch after each reading. Also, this can minimize the change of e.m.f. E and so to obtain a more accurate result.

Conclusion:

In the experiment, the voltmeter-ammeter method has been used to find the e.m.f. and internal resistance of a cell. Based on the result of experiment, the internal resistance of the cell was 15.0 Ω and its e.m.f. E was 2.92 V.

Alternative Method (R - 1/I graph):

Graph (2): The Relationship between External Resistance and Reciprocal of Current



The table below illustrates the considerable scope which teachers have in choosing practical work for SBA. It is hoped that this can help teachers plan their teaching and assessment arrangement. However, teachers should feel free to devise their own innovative or/and project-based practical activities for assessment in particular areas of the syllabus as long as they are **of appropriate standard** and can meet the criteria for awarding marks. **There is no list of prescribed or recommended practical work which must be used for assessment purposes** since teaching interests and resources vary from school to school.

Some suggested experimental work	*Syllabus Topic of HKDSE*	*Suitable for assessment*
Measurement of the specific heat capacity of a liquid using a low voltage immersion heater and a foam cup.	(I)	✓
Measurement of the specific latent heat of fusion of ice using a low voltage immersion heater.	(I)	✓
Measurement of the specific latent heat of vaporization of water using a mains heater.	(I)	✓
Cooling curve of octadecan-1-ol.	(I)	
Investigation of the relationship between pressure, volume and temperature of a gas.	(I)	✓
Study the effects of the normal force, materials involved and surface area on the force of friction using a block.	(II)	✓
Investigation of the relationship between (a) acceleration and force when the mass is constant; and (b) acceleration and mass under a constant force.	(II)	✓
Measuring g by simple pendulum / spring-mass system / HDMVA method.	(II)	✓
Finding the C.G. of lamina with irregular shapes	(II)	✓
Finding an unknown mass by balancing a ruler on a knife-edge using standard weights	(II)	
Conservation of linear momentum in elastic/inelastic collision of trolleys (further investigation on loss of kinetic energy in inelastic collisions).	(II)	✓
Experimental test of $F = \frac{mv^2}{r}$ by whirling a rubber bung.	(II)	✓
Ripple Tank Experiments.	(III)	✓
Measuring critical angle and refractive index of a semi-circular plastic block.	(III)	✓
Stationary wave pattern at different frequencies using a signal generator.	(III)	
Estimation of the wavelength of light using (a) double slit; and (b) plane diffraction grating.	(III)	✓
Measurement of focal length of convex lenses by different methods: (a) image formation of a distant object; (b) plane mirror method; and (c) lens formula.	(III)	✓
Finding the wavelength / wave speed of sound wave by interference of sound waves using two loudspeakers and CRO.	(III)	✓

(Revised as of 28 October 2013)

Some suggested experimental work	*Syllabus Topic of HKDSE*	*Suitable for assessment*
Drop in terminal p.d. of power supplies delivering current and using different voltmeters to measure the terminal p.d. of a power supply with high internal resistance.	(IV)	✓
Using a current balance to measure the magnetic fields (a) between two magnadur magnets; (b) close to the end of a current-carrying coil; and (c) inside a flat solenoid carrying current.	(IV)	✓
Using a Hall probe or a search coil to investigate the magnetic fields (a) around a long straight wire; (b) at the centre of a coil; (c) inside and around a slinky solenoid; and (d) inside a solenoid, carrying current.	(IV)	✓
Investigation of the factors affecting the induced e.m.f. in a coil.	(IV)	✓
Study of transformer action : (a) the effect of the flux linkage; (b) the relationship between voltage ratio and turn ratio; (c) the dependence of the current in the primary coil on the loading; and (d) comparison between input and output power.	(IV)	✓
(a) Measurement of the resistance of a conductor with a voltmeter and an ammeter (Ohm's law). (b) Change of the resistance of filament of a lamp with temperature. (c) Change of the resistance of a conductor with its length and cross-sectional area.	(IV)	✓
Measurement of the internal resistance of a battery.	(IV)	✓
Measurement of the power output of a battery with time	(IV)	✓
Study of the factors affecting the strength of an electromagnet.	(IV)	✓
Use of the oscilloscope as a d.c. and an a.c. voltmeter, for waveform display and time base for frequency measurement.	-	
Study the relationship between light intensity of a light bulb with distance by a light meter.	(VIII)	✓

PLK Lo Kit Sing (1983) College, Tsing Yi
Practical Physics – prepared by Mr Law Man Wai

Name: _____ CSNO: _____ Group: _____

Determine the characteristic of a non-ohmic device

Technique	
Result	
Discussion	
C.O.	
Total	

Objective:

To determine the internal resistance of a battery.

Apparatus:

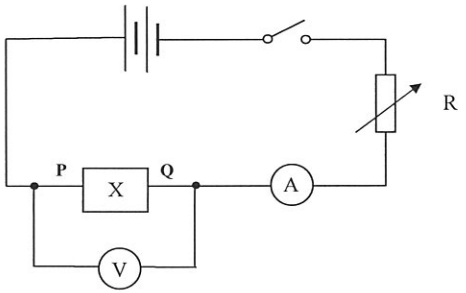
- Device X
- Battery
- 5 V Voltmeter
- 1 A Ammeter
- Rheostat R
- Connecting wires
- Switch

Theory

An ohmic device is an electrical device which obeys Ohm's law, i.e., voltage drop is proportional to current. In this experiment, we are going to find the characteristic of a non-ohmic device. The *characteristic* is represented by the voltage-current graph of the device. Using this voltage-current characteristic curve, we are going to solve some problems.

Procedures

1. Connect the circuit as shown in the diagram below using *two cells. Make sure X is connected in the correct polarity* (with P connected to positive pole of battery). Mark the number labeled on X in the box on the right.



Label on X:

2. Set the rheostat to the maximum value. Turn on the switch and adjust the rheostat until current is 0.1 A. Take the reading of the voltmeter. Turn off the switch when you have finished taking reading.
3. Reduce the resistance of the rheostat to set the current to the other values in the table. Take the corresponding reading of the voltmeter. Remember to turn off the switch once you have finished taking reading.
4. As the rheostat reaches the minimum value, switch off the circuit and add two more cells to the battery. Set the rheostat to the maximum resistance once again. Turn on the switch and adjust the rheostat to get the next currents in the table.
5. If there are some large currents in the table that cannot be reached even when the rheostat is set to minimum, cross out (×) those boxes in the table.
6. Plot the voltage *V* against the current *I*.

Ammeter reading *I*/A	0.10	0.14	0.18	0.22	0.26	0.30
Voltmeter reading *V*/V						

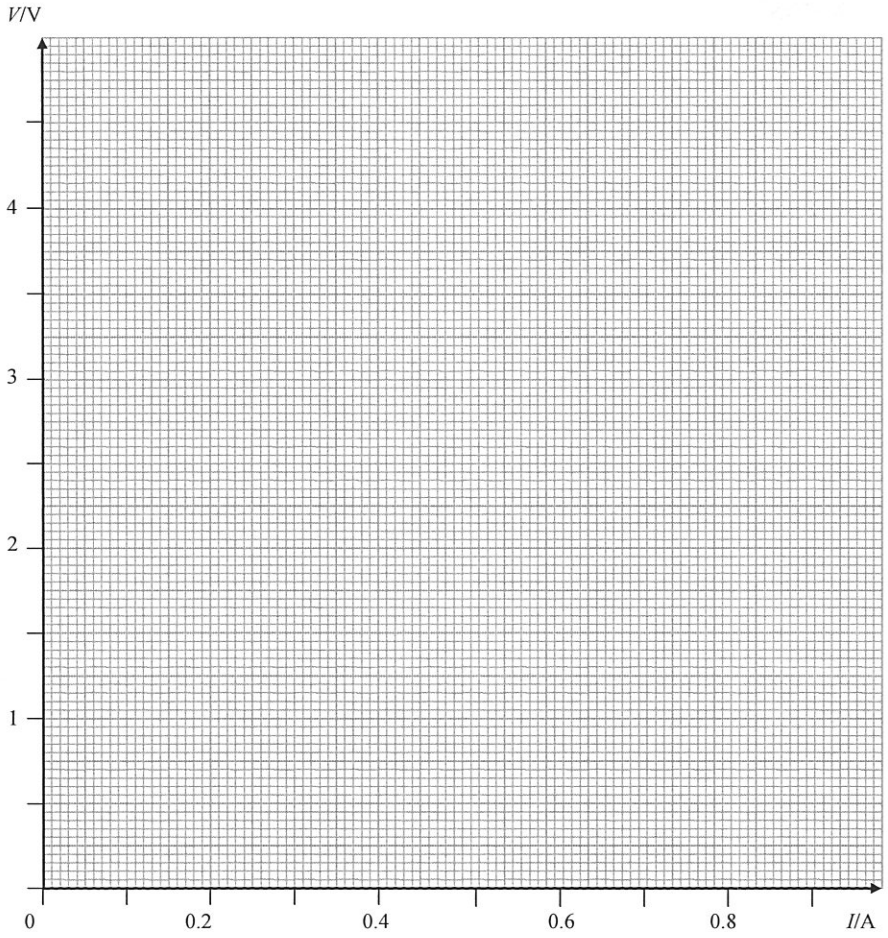
0.34	0.40	0.50	0.60	0.70	0.80

7. Repeat the experiment with the polarity of X *reversed* (i.e., Q is connected to positive pole of the battery).

Ammeter reading *I*/A	0.10	0.14	0.18	0.22	0.26	0.30
Voltmeter reading *V*/V						

0.34	0.40	0.50	0.60	0.70	0.80

Plot a graph of the V against I for the above two set of results. Mark the first set of result as ***trial 1*** and the second set of result ***trial 2***.



Does X obey Ohm's law in trial 1 ? _____

Does X obey Ohm's law in trial 2 ? _____

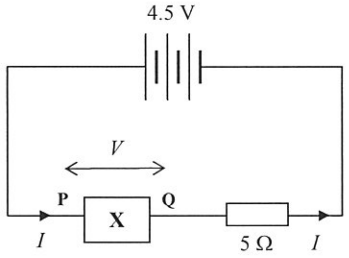
Discussion

1. What is the advantage of changing the resistance of rheostat from large to small instead of small to large value when different sets of readings of V and I are taken ?

2. Why is it necessary to turn off the switch after each reading is taken ?

3. The battery has an internal resistance of a few ohms. Does the internal resistance of the battery give rise to any error in the V-I characteristic of device X ? Explain briefly.

4. Device X is connected in series with a 5 Ω resistor to a 4.5 V battery. The current and voltage drop of X is I and V respectively. Write down an equation to express V in terms of I by considering the circuit below.

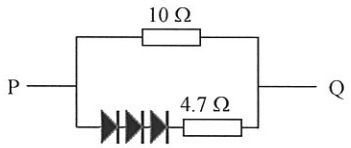


5. Plot a line to represent the equation of V and I you have derived in (4) in the graph on P.3.
6. From the graph find the value of I in the above circuit. Explain your answer briefly.

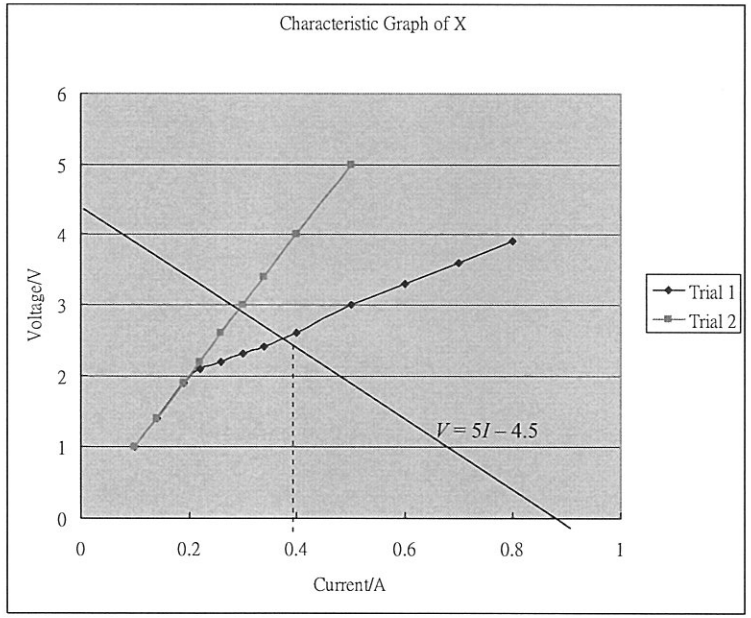
I = _____ A

- END -

Typical circuit of device X



I/A	0.1	0.14	0.19	0.22	0.26	0.3	0.34	0.4	0.5	0.6	0.7	0.8
Trial 1/V	1	1.4	1.9	2.1	2.2	2.3	2.4	2.6	3	3.3	3.6	3.9
Trial 2/V	1	1.4	1.9	2.2	2.6	3	3.4	4	5	×	×	×



Working current of circuit in worksheet = 0.39 A

Making and Evaluating an Electrical Battery

Adam Niculescu and Peter Martin, Virginia Commonwealth University, Richmond, VA

This paper describes an experiment that can be used to introduce the operation and working parameters of a battery to either high school or college students. The experiment shows students how to use a simple cell to light an LED and how to measure current, voltage, and power when they are changing with time. The experiment can be extended to show how effective electrode area controls the current and voltage, and how to measure the internal resistance of the battery.

It is estimated that the U.S. battery market alone will continue to grow 5.5% annually to reach $14 billion in 2007.[1,2] Each month more than 50 global patents are being issued on battery-related technology, and what used to be a mature industry concerned with carbon-zinc and lead-acid technology has blossomed into the rapidly growing segments of alkali, lithium, silver, nickel metal hydride, and rechargeable batteries. Without this technology, the average student's day would come to a grinding halt: no calculators, no iPods, no music, and no cars.

There is a demonstrated need[3] for physics courses, especially those not targeting science majors, to allow students to see the relevance of what they learn in class to their everyday life. The battery is an ideal topic since it incorporates the fundamental concepts of electricity generation and transfer, while exposing students to the practical aspects of constructing an electrical circuit and the meaning and measurement of current, voltage, power, and load. Once they understand these basics, it is hoped that they will appreciate why there is such a range of battery technology available and how the different commercial products that are part of their everyday experience differ from each other.

The project, which is described below, can be used in any introductory or conceptual physics course at the high school or college level. It has the students make a simple battery cell and assess its performance. The level of assessment can be varied according to the time available and the ability of the students.

Every battery cell[4] has a positive and a negative electrode. These electrodes are immersed in an electrolyte that permits the passage of ions between the electrodes. The electrode materials and electrolyte are chosen and arranged so that sufficient electromotive force and electric current can be developed between the terminals to operate lights, machines, or other devices. Since an electrode contains only a limited number of units of chemical energy convertible to electrical energy, it follows that a battery of a given size has a certain capacity to operate devices and will eventually become exhausted. Battery usefulness is limited not only by capacity but also by how fast current can be drawn from it. The salt ions chosen for the electrolyte solution must be able to move fast enough through the solvent to carry chemical matter between the electrodes equal to the rate of electrical demand. Battery performance is thus limited by the diffusion rates of internal chemicals as well as by capacity.

The voltage of an individual cell and the diffusion rates inside it are also influenced by the temperature of the electrolyte and are both reduced if the temperature is lowered from room temperature. If the temperature is raised deliberately, faster discharge can be sustained,

 DOI: 10.1119/1.2336133

but this is not generally advisable because the battery chemicals may evaporate or react spontaneously with one another leading to early failure.

Within the battery, the negative ions of the electrolyte are pushed toward the negative terminal (and positive ions toward the positive terminal). The electrolyte resists the flow of ions, the internal resistance r of the battery. Thus, the total resistance of the circuit containing an external resistor of electrical resistance R and a battery is the sum of the resistance of the external resistor and the internal resistance of the battery.

The electromotive force (emf) ε generates a current I flowing through the resistance R and the internal resistance r. Ohm's law is then written as

$$\varepsilon = (R + r)\, I. \tag{1}$$

The potential drop of the external resistance R is

$$V = R\, I \tag{2}$$

and is less than the emf, by the amount $r\, I$.

Although the battery described below is not designed for commercial use, it is well-suited for illustration of the principles involved in its operation.

Making the Battery[5]

Kits for making this type of battery are available in scientific catalogs such as Fisher Scientific[6] or Carolina.[7] The necessary materials to perform the steps described in this paper are given below.

- plastic cups (2)
- copper electrodes (2)
- zinc electrodes (2)
- (coated) paper clips (4)
- red light emitting diode (LED) (low current and high light output) (1)
- alligator clip leads (3)
- 1000-Ω resistor (1)
- 500-Ω resistor (1)
- container for preparation of the solution
- table salt (not ionized)
- stopwatch
- sandpaper (to clean the electrodes)
- multimeters (2)

The assembled battery cell is shown in Fig. 1. The

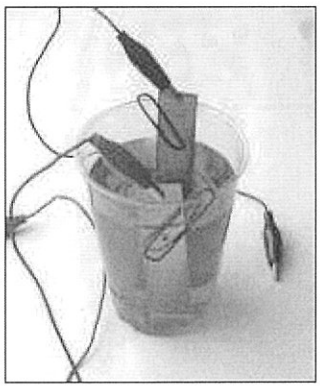


Fig. 1. Battery cell containing a copper and a zinc electrode immersed in a table salt solution. When performing different steps of the experiment, the salt solution level should be maintained the same.

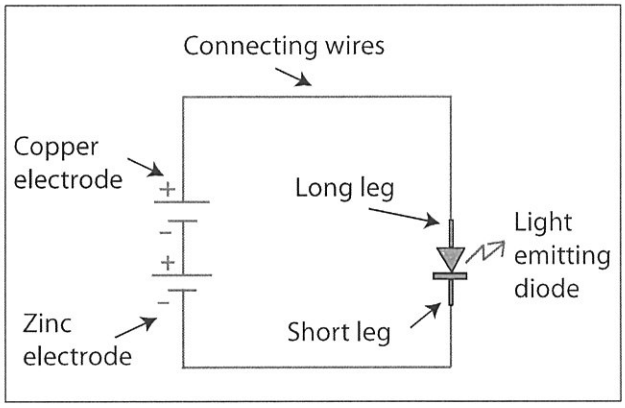


Fig. 2. Circuit diagram of an LED connected to the battery containing two cells in series.

copper and zinc electrodes are set vertically inside the plastic cup and are anchored to opposite sides with coated paper clips. A saturated solution of table salt in tap water is poured into the cup.

An intuitive way to show that the cell is a source of electrical energy is by lighting an LED. The power output of this type of cell is relatively low. The red LED requires a low current to operate. It fires at around 1.7 V, while the cell just made puts out close to 0.8 V. Two cells connected in series (a two-cell battery) should do the trick, though. The second cell should be made identical to the first one.

For the cells to be in series, the zinc electrode of the first cell is connected with the copper electrode of the second one with an electrical lead provided. Now the battery terminals of the system of the two cells are the copper electrode of the first cell and the zinc electrode of the second one.

When examining the LED, one will notice that one of the legs is longer than the other. Connect the long leg of the LED to the copper electrode and the short

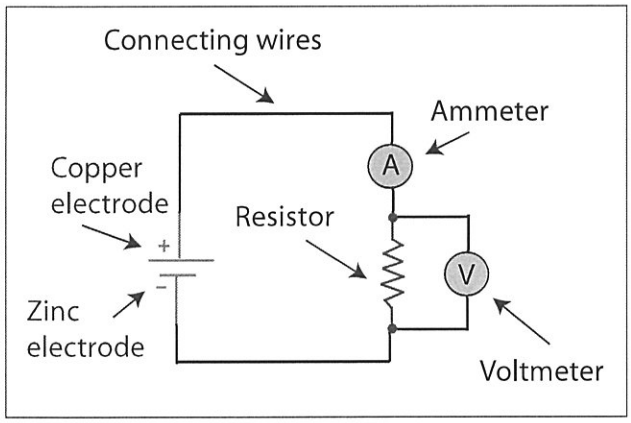


Fig. 3. Circuit for measuring the voltage across—and current through—the resistor.

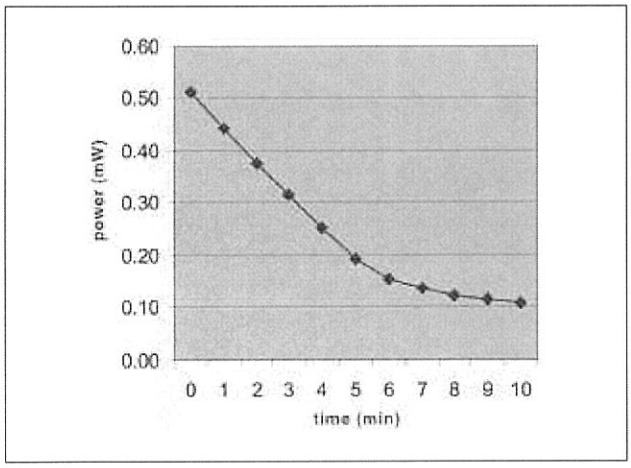


Fig. 4. Time dependence of the power dissipated in the 1000-Ω resistor.

one to the zinc electrode. Figure 2 gives a diagram of the circuit. If everything was done right, the red LED will light up to demonstrate that even the simple cell can be used to generate a practical quantity of electricity.

Battery Performance

Power and energy

The purpose of the second part of the experiment is to see how different components of the battery influence its performance. First, a measurement of the open circuit voltage is performed. An open circuit is when no load (that dissipates energy) is placed in the circuit. Next, a circuit containing one cell and a 1000-Ω resistor is made. Measurements are made by inserting the ammeter and the voltmeter in the circuit (see Fig. 3).

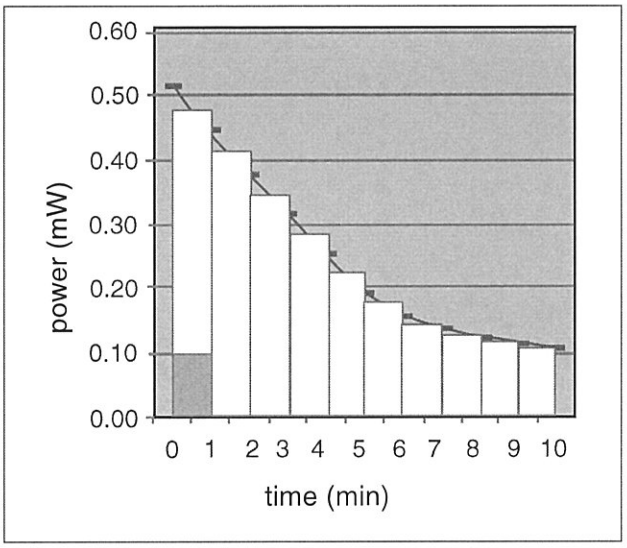


Fig. 5. Computing the energy dissipated in the 1000-Ω resistor for the 10-min interval.

Taking readings of the voltage and current every minute shows that the output of the cell decreases quickly. Table I gives sample data of the readings taken at one-minute intervals.

Note that there is a direct proportionality between the current (measured in amperes) and the voltage (measured in volts) with the constant of proportionality being 1000, which is the value of the resistor in the circuit. This verifies Ohm's law (Eq. [2]).

From the data given in Table I one can calculate the power P dissipated in the resistor:

$$P = VI. \tag{3}$$

The time dependence of the power dissipated in the resistor is shown in Fig. 4.

One can go one step further and find the amount of energy put out by the battery for the period when the measurements were made.[8] At any instant in time, the energy delivered (E) can be found by multiplying the power delivered with the time interval that power was delivered. Thus,

$$E = P \times \text{time interval} \tag{4}$$

(one assumes that the power delivered in a short time interval is constant). The power does not remain constant in time as shown in Fig. 4; however, one could use a simple method to approximate the

Table I. Voltage and current measured at 1-min intervals.

Reading #	Current (mA)	Voltage (V)
0	0.71	0.72
1	0.66	0.67
2	0.61	0.61
3	0.56	0.56
4	0.50	0.50
5	0.43	0.44
6	0.40	0.40
7	0.37	0.37
8	0.35	0.35
9	0.35	0.34
10	0.33	0.33
The open-circuit voltage: 0.78 V 1 mA = 1/1000 A		

energy dissipated through the following line of reasoning (see Fig. 5).

When plotting the *constant* power (such as the 0.1 mW) dissipated in a resistor in a period of time such as one minute (see the shaded rectangle shown in Fig. 5 on the lower left side), the energy dissipated is numerically equal to the area of the rectangle (0.1 mW × 60 s = 6 mJ). Now, if the power changes in time as in this case, one could assume that for very short periods of time the power dissipated stays constant, so the graph will take the appearance of narrow rectangular slices for which one could compute the energy dissipated. Ultimately, that will lead to the fact that the energy dissipated for the entire period is numerically equal to the area under the curve of the power-versus-time graph. One can approximate the areas under the curve for each minute interval with rectangles as shown in the figure. In this case the energy delivered within the 10-min interval was found to be 144 mJ.

Internal resistance of the battery

As shown in Table I, the open-circuit voltage across the cell was found to be 0.78 V, while the initial voltage across the resistor was 0.72 V. The balance of 0.06 V is the voltage drop across the internal resistance of the cell. It is instructive to check this out.

The electromotive force ε of a battery (which is the open-circuit voltage) is related to the electric current I flowing through the resistor R and the internal resistance r by Eq. (1).

In order to measure the internal resistance of the cell, one can make a solution with the same concentration of salt as in the experiment above and insert two copper electrodes on the opposite sides of the cup. One can measure the resistance with the ohmmeter function of the multimeter. The resistance found in our trials was around 110 Ω. This is close to the value calculated from the above Eq. (1).

$$r = \varepsilon/I - R = 0.78\ \text{V}/\ 0.00071\ \text{A} - 1000\ \Omega = 98\ \Omega.$$

(Note: the resistance between the electrodes in the same configuration and using distilled water instead of salt solution is 92 kΩ).

Effect of the electrode surface area

The effect of the doubling of the electrodes' surface area on the electric output of the battery can be checked by connecting two copper electrodes together and two zinc electrodes effectively doubling the surface area of the electrodes. Will the output change? When measuring the voltage change versus time for this configuration, we found that the voltage decreases slower in time than in the experiment with single electrodes (see Fig. 6).

It follows that in the new configuration the energy delivered to the resistor increases compared with single electrodes.

Influence of the magnitude of external resistance

The above measurements were made with one 1000-Ω resistor. If one decreases the value of the external resistance, one would expect the value of the current to increase; thus, the battery would discharge more rapidly. Indeed, when the 1000-Ω resistor was replaced with a 500-Ω one, the voltage across the resistor decreased faster, as shown in Fig. 7.

A simple computation shows that in this case the current flowing through the external circuit is doubled from the 1000 Ω, so the battery is discharged faster. If one replaces the 500-Ω resistor with a 100-Ω one, the battery will be discharged even faster.

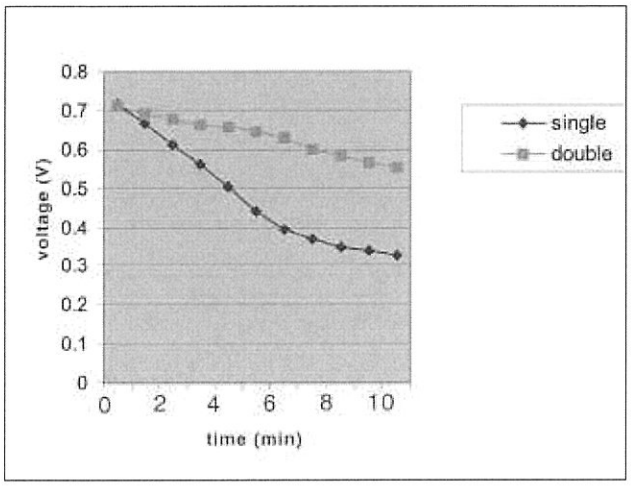


Fig. 6. Time dependence of voltage for single and double electrodes.

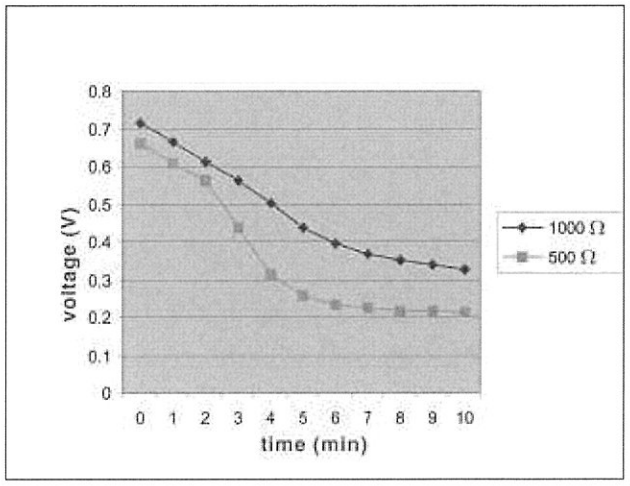


Fig. 7. Time dependence of the voltage across two different resistors.

Conclusions

This experiment has proven to be an effective introduction to the concept of a battery, its operation, and the parameters defining its capabilities. It can easily be expanded to show how the electrical parameters are affected by using different materials for the electrodes (carbon, iron, and aluminum give good data), and the electrolyte (lemon juice, sodas, and di-ionized water provide interesting results), and to show the effects of combining batteries in series and in parallel. The "Wonders of Technology" course for which the experiment was originally developed also requires each student to undertake a short experimental research project at the end of the semester. Students have built on their learning from this experiment to carry out projects comparing the lifetimes of different commercial batteries and to show how the electrical output is affected by the salt concentration of the electrolyte or the temperature of the battery.

References

1. *Battery Technology Research Report* (Freedonia Group Inc., 2003).
2. "Battery and EV industry review," *Bus. Commun. Co.* (March 2004).
3. E. Seymour, "Revisiting the 'problem iceberg': Science, mathematics and engineering students still chilled out," *J. Coll. Sci. Teach.* 24(6), 392 (May 1995).
4. Details on battery operation can be found in many easily accessible sources such as the Encyclopedia Encarta, http://encarta.msn.com, or http://www.howstuffworks.com/battery1.htm.
5. Parts of this article are developed as a lab experiment in Adam Niculescu's *Wonders of Technology,* 3rd ed. (John Wiley and Sons, 2005).
6. Fisher Scientific, http://www.fisherscientific.com/; https://www1.fishersci.com/index.jsp.
7. Carolina, http://www.carolina.com.
8. The energy delivered is given by the area under the curve $P(t)$, by $E = \int P(t)dt$. The procedure given in this article can be used by students who are not familiar with calculus.

PACS codes: 06.60.-c, 07.50.e

Adam Niculescu, *associate professor of physics at Virginia Commonwealth University, received his Ph.D. at the University of Bucharest, Romania. He is the author of the conceptual physics text:* Wonders of Technology, *Wiley, 1999, 2000, 2005.*

Physics Department, Virginia Commonwealth University, 1020 West Main, Richmond, VA 23284; vanicule@vcu.edu

Peter Martin *became an adjunct faculty member of the Virginia Commonwealth University in 1998 when he retired after 27 years of experience in industrial R&D. He has an M.A. from Cambridge University and a Ph.D. from the College of William and Mary in Virginia, and is interested in developing and assessing physics courses for nonscientists.*

Physics Department, Virginia Commonwealth University, 1020 West Main, Richmond, VA 23284; pmartin@vcu.edu

*Name :*_____

*Class :*_____

Date : _____

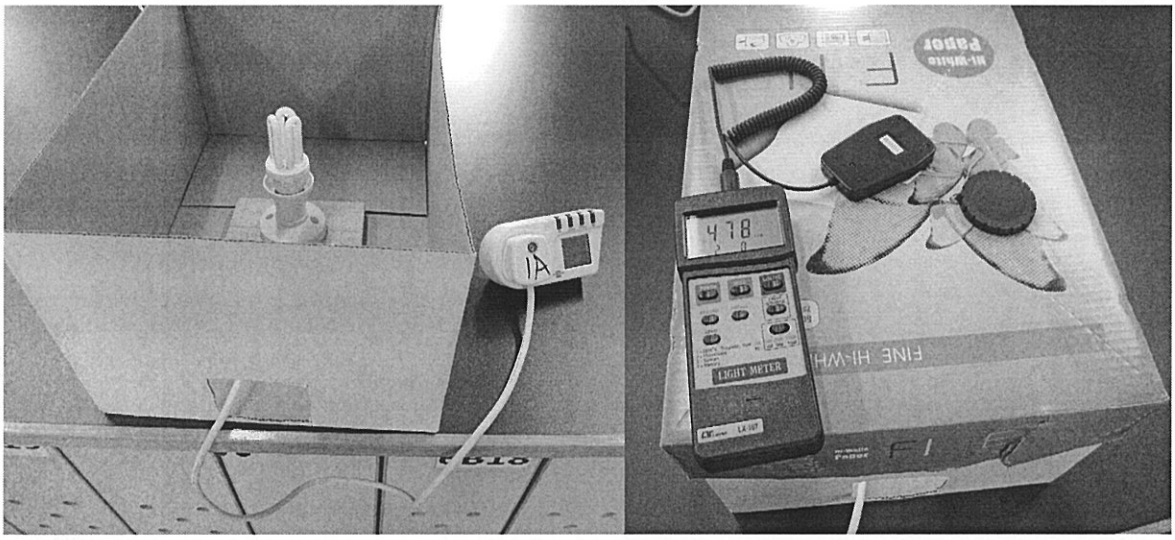
St. Francis Xavier's School, Tsuen Wan
Practical Physics – prepared by Mr Chung On Wing

Experiment 3: Measuring the luminous flux emitted by a light source and Find the energy efficiency of the Source

Apparatus: 1 lampstand, 1 light source, 1 wattmeter, 1 illuminance meter, 1 half-metre ruler, 1 box

Experiment:

1. Set up the apparatus as shown below.



Connect the lampstand and the mains supply via an a.c. wattmeter.
Turn on the power and the wattmeter. Wait for about 2 – 3 minutes for the wattmeter reading to stabilize.

The light source is _____

Input electrical power P (record the reading of the wattmeter): _____

Illuminance E (record the reading of the illuminance meter): _____

Distance between the lamp and the illuminance meter r: _____

2. Calculate the luminous flux by applying $E = \dfrac{\Phi}{4\pi r^2}$.

$\Phi = 4\pi r^2 \times E =$ _____

$\text{Efficacy} = \dfrac{\text{luminous flux}}{\text{input electrical power}} = \dfrac{\Phi}{P} =$ _____

The experimental value is [larger than / within the range of / smaller than] the typical value of the light source.

Multiple-Choice Questions, HKDSE

Most Favourable Distractor

2012				2013			
Paper 1A		Paper 2		Paper 1A		Paper 2	
1.	D (21%)	1.1	B (36%)	1.	D (37%)	1.1	A (10%)
2.	B (12%)	1.2	D (26%)	2.	C (24%)	1.2	C (29%)
3.	B (33%)	1.3	C (18%)	3.	A (28%)	1.3	C (21%)
4.	C (17%)	1.4	B (20%)	4.	A (20%)	1.4	C (43%)
5.	D (28%)	1.5	D (30%)	5.	D (23%)	1.5	C (39%)
6.	C (24%)	1.6	D (26%)	6.	B (22%)	1.6	A (21%)
7.	B (17%)	1.7	A (22%)	7.	D (34%)	1.7	D (19%)
8.	B (26%)	1.8	A (17%)	8.	B (37%)	1.8	A (24%)
9.	C (7%)			9.	C (14%)		
10.	A (18%)	2.1	A (25%)	10.	B (22%)	2.1	A (25%)
11.	C (16%)	2.2	D (23%)	11.	A (30%)	2.2	A (26%)
12.	D (19%)	2.3	D (27%)	12.	D (20%)	2.3	D (23%)
13.	B (19%)	2.4	B (21%)	13.	C (43%)	2.4	C (28%)
14.	C (18%)	2.5	B (23%)	14.	D (8%)	2.5	D (21%)
15.	A (14%)	2.6	B (9%)	15.	A (14%)	2.6	D (17%)
16.	B (12%)	2.7	C (27%)	16.	D (10%)	2.7	A (34%)
17.	A (11%)	2.8	A (22%)	17.	C (18%)	2.8	D (36%)
18.	C (18%)			18.	B (23%)		
19.	C (12%)	3.1	D (10%)	19.	D (26%)	3.1	B (28%)
20.	C (17%)	3.2	B (26%)	20.	D (15%)	3.2	A (11%)
21.	B (28%)	3.3	C (34%)	21.	C (23%)	3.3	A (11%)
22.	C (25%)	3.4	D (14%)	22.	A (23%)	3.4	C (18%)
23.	D (23%)	3.5	C (7%)	23.	C (24%)	3.5	A (19%)
24.	C (7%)	3.6	C (12%)	24.	C (20%)	3.6	C (52%)
25.	D (30%)	3.7	A (11%)	25.	B (20%)	3.7	C (12%)
26.	C (18%)	3.8	D (38%)	26.	B (29%)	3.8	A (18%)
27.	C (19%)			27.	A (17%)		
28.	D (30%)	4.1	B (23%)	28.	A (23%)	4.1	C (30%)
29.	A (21%)	4.2	A (35%)	29.	C (26%)	4.2	B (24%)
30.	D (24%)	4.3	A (26%)	30.	C (31%)	4.3	B (30%)
31.	D (22%)	4.4	D (41%)	31.	B (29%)	4.4	B (26%)
32.	C (26%)	4.5	A (22%)	32.	D (24%)	4.5	B (38%)
33.	A (40%)	4.6	B (23%)	33.	D (31%)	4.6	D (26%)
34.	B (24%)	4.7	A (21%)	34.	C (10%)	4.7	D (34%)
35.	A (16%)	4.8	C (38%)	35.	A (23%)	4.8	C (12%)
36.	B (23%)			36.	C (16%)		