Regular classroom assessment as a means of enhancing Teacher Trainees' understanding of concepts in electricity and magnetism

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Abstract

This study was an action research which employed regular classroom tests to help students learn and understand some concepts in electricity and magnetism. The participants of the study were 35 Level 200 B.Ed. (Basic Education, JSS Option) pre-service science teachers of the University of Education, Winneba in the Central Region of Ghana. The first phase of the study consisted of a pre-intervention test to gauge the level of the pre-service teachers. The second phase was the implementation of the intervention. The pre-service science teachers were taught for twelve weeks and made to take an essay-type test fortnightly on the concepts they have learnt within the week and the previous weeks. The study used qualitative and quantitative data gathering instruments, pre-service teachers' fortnightly tests and end-of-semester examination. The test items used were teacher-constructed based on the cognitive level of the students and the instructional objectives stipulated in the course outline. Most of the responses the pre-service science teachers provided in the fortnightly tests reflected understanding of the concepts learnt. The tests motivated the pre-service teachers to learn which resulted in an improvement in their understanding of concepts in the concepts being taught. The outcome of the study shows that pre-service science teachers should be tested regularly in the classroom in order to maximize their learning output.

Keywords pre-service science teachers, regular classroom tests, concept of electricity and magnetism

Background to the study

One of the visions of Ghana government on education is raising the quality of teaching and learning for effective outcomes. In order to help evaluate teaching and learning effectively there have been a quest by researchers to find out assessment methods which motivate, promote and improve the learning and understanding of concepts. Classroom tests have been identified as one of the powerful assessment tools in the classroom. In Most Ghanaian schools and including tertiary institutions, classroom tests are employed to grade students and also place students on courses. But its impact on teaching and learning in the classroom has not been fully utilized in majority of schools in Ghana. Experience from the researcher's teaching over several years has shown that students put much effort in their studies whenever time for tests and examination are announced.

Testing students regularly may serve as reinforcement for students to learn. Feedback from regular classroom tests may be useful to teachers in assessing whether the students are learning what they are expected to learn. To be the best possible

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professional in the teaching business, a teacher must keep learning and adapting new skills. This only can come from being reflective in the practice, as according to Featherston (2007), reflection on action leads to identification of processes, experiences, and understandings that can then be used in future lessons. Effective teachers therefore know how to coordinate diverse array of instructional elements (such as planning, lesson design, time management, classroom management, instructional methods, student motivation, and assessment techniques) and adapt them to differences in student needs, materials and purposes (Snowman et. al, 2009). Hence the objective of this study, that is, how regular classroom assessment can be used to enhance pre-service science teachers understanding of some basic concepts in physics, especially, electricity and magnetism and more specifically, helping teacher trainees to develop a conceptual understanding of physics principles.

The research setting

The Department of Basic Education in the University of Education, Winneba (UEW) was established in the year 2001 to train teachers to teach effectively at the Primary and Junior High Junior (or Secondary) School (JHS) levels of Ghana's educational system. The Department has, since its inception, been producing broad based trained classroom teachers for primary school as well as JHS and administrators for district and zonal offices of the Ghana Education Service (GES).

Statement of the problem

Testing in the classroom is one of the routine activities that engage teachers and students. The use of classroom tests in Ghanaian classrooms appears to be limited to determining students' learning only. It is however, noted from the literature that tests may be used to help students' learning. Thus, when a teacher uses tests for formative purposes, students are able to learn what went wrong with their learning and also how to correct their errors. In the Ghanaian classroom, however, the trend appears to be the use of tests to determine the extent of learning rather than the depth of understanding of the topics taught. This study will devise an intervention in a science classroom to use regular class tests in a formative way to help students learn and understand some basic concepts in Physics. The study was therefore guided by the following research question: What effect has regular classroom tests on pre-service science teachers' understanding of concepts in basic electricity and magnetism?

Literature review

Assessments and Tests

Assessment of students' learning has become a topic of great emphasis in educational literature nowadays (Shavelson, Carey, & Webb, 1990; Zoller, Ben-Chaim, & Kamm, 1997). The relationship between assessment and students' learning has been widely researched (Brookhart, 1997; Tittle, 1994). These studies found that assessments measuring clearly identified learning targets, fairly scored reduced anxiety and lead to students' learning. According to Black and William (1998; 2004), assessment refers to all activities teachers use to help students learn and to evaluate their progress. The main goal of classroom assessments is to obtain valid, reliable, meaningful, and appropriate information about student learning (Linn & Gronlund, 1995).

Assessments provide feedback to students and information to teachers about students' performance in a course. There are two main forms of assessment practised in the classroom. These are summative assessment and formative assessment. According to Garrison and Ehringhaus (2007) summative assessment is a form of assessment used to determine the overall performance of students at the end of a course or a term. Summative assessment serves as a means to evaluate students' learning relative to content standards and course objectives. On the other hand formative assessment is a self reflective process that intends to promote students attainments (Crooks, 2001). Formative assessment helps teachers to monitor their students' progress and modify instructions accordingly. The concept of assessment is often used synonymously with test. Tests are one of the ways of measuring students' progress and are integral to accountability of an education system. Tests can be classified as criterion-referenced and norm-referenced. Criterion-referenced tests is used when the performance of students are measured against defined criteria. Norm-referenced tests on the other hand is employed when the performance of individual students are compared.

Tests as a means of assessing students' achievements in the classroom have been a contentious issue in the educational circles. Test advocates argue that regular classroom testing would increase instructional effectiveness and would encourage students to study and revise more often. Frequent testing also provides opportunities for teachers to correct students' errors, to reward good performance, and to give students a good indication of what they were expected to learn. On the other hand, opponents of regular testing are of the view that frequent classroom testing could take away instructional time. In general, classroom tests are used by teachers to diagnose students' strengths and weaknesses, monitor each student's progress, determine teacher's own instructional effectiveness and help teachers to clarify their instructional intentions (McLean & Lockwood, 1996). How much formative use can be made of a written test depends on the quality of the test design (Minstrell & van Zee, 2003). Therefore, classroom assessments that facilitate learning require careful consideration as to how they may elicit responses from students and how they tax students' thinking (Herman & Baker, 2005; Herman, Osmundson, Ayala, Schneider, & Timms, 2005; Chappuis, & Chappuis, 2007). Frequent testing usually offer students feedback of their results giving them the opportunity to see their areas of strengths and weakness. This gives them more time to work towards eliminating the areas of their weaknesses. If students performance in a course are regularly reviewed and feedback given to them they can dispel any mystery surrounding successful achievement. This is the basis of the study.

Action Research

According to Mills (2000), action research is a method within the qualitative inquiry tradition that seeks to improve professional practice through better understanding of a particular aspect of a situation. Again, Creswell (2008) states that action research is the most commonly applied practical research design in education today, since according to Altrichter (1993, p.48), "unlike many other research and development approaches, action research does not want to replace the practitioners' thinking by expert knowledge but rather aims to build on it and to support it". Thus, action research is distinguished from other forms of research by the fact that researchers are investigating their own practices, that is, when faced with a problem, the teacher goes through a series of phases (reflect, plan, action, observe) called the Action Research Cycle to systematically tackle the problem. The cyclic process alternates between action and critical reflection (Dick, 2002). According to Dick (2002), as the cycle progresses, a greater understanding is developed through the continuous refining of methods, data and interpretation. It seeks to describe, interpret and explain events whilst seeking to effect changes. The goal of action research is to experiment with making a positive difference in one's professional practice as the research is conducted. Creswell (2008), continued by saying that teachers reflect on what worked well and what did not, what needs adjustment, and what should be discarded altogether. He concluded that teachers also consider what new practices hold promise for the academic attainment of their students. Mills (2000) believes that the purpose for choosing action research is to effect positive educational change.

Methodology

Research Design

This study is an action research which aims at improving students' learning and understanding of concepts in basic electricity. Action research was chosen because it improves teacher's classroom practice and enhances students' learning, and also promotes personal and professional growth of the teacher (Johnson, 1995). Normally in the teaching learning process, when faced with a problem, the action researcher will go through a series of phases (reflect, plan, action, observe) called the Action Research Cycle to systematically tackle the problem (McNiff & Whitehead, 2005) which is summarized Figure 1.

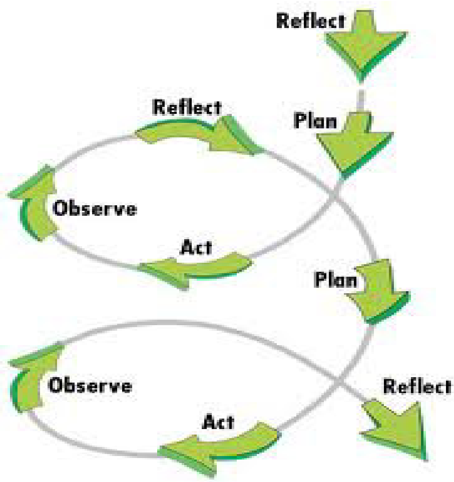


Fig. 1 Action Research Cycle [adapted from (CELT, 2012)]

This study was carried out in two phases. The first phase consisted of pre-intervention activities, whiles the second phase was the post-intervention activities.

Target group and data collection procedure

The target population for this study was all 35 (33 males, 2 females) Level 200 B.Ed. (Basic Education) (JSS Option) pre-service science teachers taking a course in '*electricity and magnetism'* in as semester. These are mature students, average age 30 years, who have been teaching at the basic education level for at least five years after completing their initial teacher training.

The pre-service science teachers' fortnightly tests and end-of-semester examination constituted the main data collection instruments. The test items were those constructed by the lecturer based on the cognitive level of the pre-service teachers and the instructional objectives stipulated in the course outline. The tests required the pre-service teachers to provide answers with correct explanations and examples showing application of the principles learnt. Data from the tests and end-of-semester examination therefore yielded both qualitative and quantitative. The pre-service teachers were taught for twelve weeks, the normal teaching period for the semester.

The action research procedure

The pre-service science teachers were taken through the course content of electricity and magnetism, which is a 3 credit course at the pre-intervention stage of the study. The pre-service teachers were then given a one-hour test before the intervention. They were then taken through weekly lectures with respect to the course content which consisted of such learning activities as lecture and demonstrations; literature search with presentations; peer critique; classroom training sessions; group work and discussions; seminar presentations; and out-of-class and in-class assignment (*practical sessions/fieldwork*). The course content of electricity and magnetism, covered during the twelve week intervention included the basic force relationship between two charges which acts along the line connecting the charges and is repulsive for like charges and attractive for unlike charges. Table 1 shows the sub-topics taught every fortnight during the intervention.

To help students learn and understand electricity and magnetism better, questions asked were constructed with increasing cognitive demand. These posed a challenge to students to reason and apply the principles learnt in solving them. The test results were given to students before the first lesson of the next week. This helped students to get enough time to do remediation on the concepts they could not provide valid responses to. Descriptive feedback in the form of written comments was provided against any incorrect responses which did not reflect understanding of concepts learnt. This assisted students to know the mistakes they committed and how to overcome such mistakes in subsequent tests. These strategies assisted students to use the best and correct approach in finding solutions to the questions asked in the subsequent tests.

Table 1 Sub-topics of electricity and magnetism taught every fortnight during the intervention.

Weeks	Content taught
1 – 2	Concepts of electric forces and electric fields, the origin of electricity, charged objects and the electric force, conductors and insulators, charging by contact and by induction.
3 – 4	Electric circuits, that is, electromotive force and current; Ohm's law; resistance and resistivity; electric power; series circuit; parallel circuits; and circuits wired partially in series and partially in parallel
5 – 6	Internal resistance; Kirchoff's laws; measurement of current and voltage; capacitors in series and parallels; R-C circuits; and safety and physiological effects of current.
7 – 8	The seventh and eighth week lectures were on Coulomb's law, the electric field, electric field lines, the electric field inside a conductor (shielding); Gauss' law.
9 – 10	Electric potential energy and electric potential; the electric potential energy; the electric potential difference; the electric potential difference created by point charges; equipotential surfaces and their relation to the electric field; Capacitors and dielectrics
11 – 12	The concepts treated in the eighth week was on magnetic and non-magnetic materials; magnetic field, processes of magnetization and demagnetization

Data collection procedure

Test items, usually lasting thirty minutes were used in fortnightly tests, which, were constructed based on the activities and concepts treated within the week and the previous weeks. Students were also given weekly assignments and practice exercises to work on their own. The test items consisted of largely essay type questions. For the situation where multiple-choice test items were used, students were to show how they arrived at the answers obtained. These items were such that they measured complicated learning outcomes and also stress on the integration and application of thinking and problem solving skills. The constructed test items were administered to the students fortnightly, marked and descriptive feedback provided on each wrong response. This was done to enable students identify their specific strengths and areas needing improvement. General discussions on the feedback of the tests were done after the distribution of the marked scripts to students. Also, students' weaknesses and misrepresentation of concepts were addressed before the next lesson. At the end of the twelfth week, students were given a two-hour test to evaluate the intervention.

Results

The results of the students' output in the pre-intervention exercises and after the implementation of the intervention are presented in Table 2 and Figure 2. The results show that the students' performance in basic electricity and magnetism before the intervention was low. Most of the responses students' provided in the pre-intervention exercise were not correct. Results in Tables 2 show that whereas 5 (14%) students before the intervention failed, that is, scored below 50%, after the intervention, no student failed. In fact, 24 (69%) students scored above 64% after the intervention as against 5 (14%) students before the intervention. This is quite commendable. Thus with the intervention which involved regular classroom tests, students' performance improved tremendously.

Table 2 Comparison of Students' Performance on Pre-intervention Test and the intervention tests

	Pre intervention		Post intervention	
Grade*	Number	Percent	Number	Percent
A	0	0	3	9
B+	0	0	4	11
B	2	6	12	34
C+	3	9	5	14
C	6	17	7	20
D+	6	17	1	3
D	13	37	3	9
E	5	14	0	0
Total	35	100	35	100

*Grading criteria: [A: 80 -100%; B+: 75-79%; B: 70-74%; C+: 65-69%; C: 60-64%; D+: 55-59%; D: 50-54%; E: <50%]

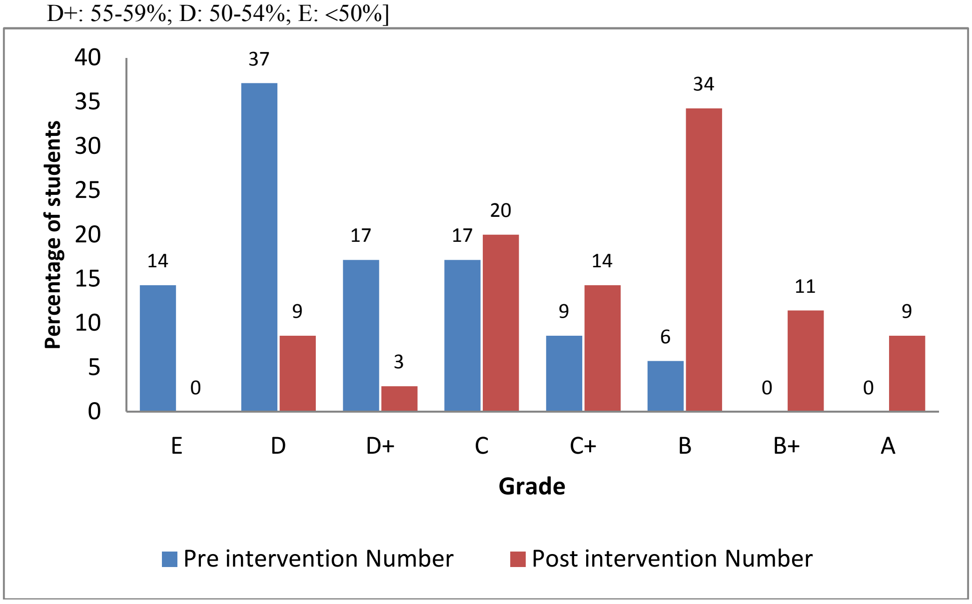


Fig. 2 Summary of students' performance on pre-intervention and end-of-semester examination

The students' difficulties in the pre-intervention test were analysed. Table 3 shows the proportion of students whose explanations demonstrated understanding and those whose explanations did not during post intervention.

Table 3 Proportion of students whose explanations demonstrate understanding or no understanding in the pre-intervention tests

	Percentage of students whose explanations demonstrate	
Test item	Understanding	No understanding
1. Three charges are arranged in the form of an equilateral triangle and students were to determine the force on one of the charges due to the other two.	20	80
2. Determine the resistance of a resistor in a glowing filament	50	50
3. Determine the resistance of (a) 35 m of 20-gauge; and (b) 75 m of 16-gauge copper wire respectively.	25	75
4. Calculate the power dissipated in each resistor of a series wound circuit.	31	69

The first test item, which was on Coulomb's law, appears abstract to most students, since 80% of the students were unable to demonstrate understanding of the concept. This law is the basic force relationship between two charges which acts along the line connecting the charges and is repulsive for like charges and attractive for unlike charges. Hence the difficulty faced by students. The next difficult test item was on resistance and resistivity, where about 75% of the students were unable to demonstrate understanding of the concept. This difficulty arose because of the 20-gauge; and 16-gauge copper wire introduced into the question. These difficulties were noted and discussed with the students. This is where the Teacher Trainees were before the intervention.

The students' difficulties in the post-intervention test were also analysed. Table 4 shows the average proportion of students whose explanations demonstrated understanding and those whose explanations did not during the post intervention.

Table 4 Average proportion of students whose explanations demonstrate **understanding or no understanding in the post-intervention tests**

	Average percent of students providing explanations	
Week	with understanding	without understanding
Weeks 1 -2	54	46
Weeks 3-4	68	32
Weeks 5-6	63	37
Weeks 7-8	84	16

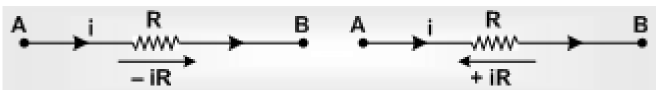
As the feedback on the tests were discussed with the students, their performance improved tremendously fortnight after fortnight, for in the last two weeks, i.e., Weeks

10-12, 90% of the students showed understanding of the concepts in Electricity and Magnetism as can be seen in Table 4. In Table 4, it can be seen that results of those not demonstrating understanding (i.e. for Weeks 3-4) has decreased drastically compared to that of the first four weeks. This was because students were very much at home with the concept of simple electric circuits than that of Kirchoff's laws of electrical networks.

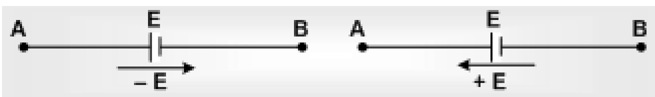
Problems encountered each week were addressed by arranging a two-hour class during the week to go through the concepts again and giving students extra practice questions to try their hands on. According to Dick (2002), as the action research cycle progresses, greater understanding is developed through the continuous refining of methods, data and interpretation in order to describe, interpret and explain events whilst seeking to effect changes. Room was also made for students still having problems to arrange for extra tuition with the lecturer.

Though remediation was provided on the students' difficulties during the teaching process, by the end of the sixth week, the students' performance in the test was not the best because they still had difficulty with the Kirchoff's laws. The difficulty stems from the fact that the students could not form the appropriate equations and assign the correct signs to the various variables. The researcher therefore exposed the students to the following signs conventions to enable them solve problems on Kirchoff's laws:

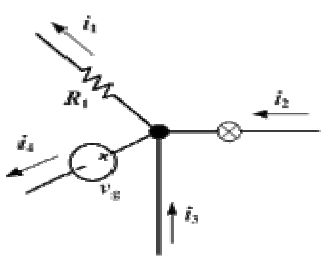
(i) The modification in potential in traversing a resistance in the direction of current is **–iR**, while in the opposite direction **+iR** as shown below.



(ii) (ii) The modification in potential in moving an electromotive (emf) source from a negative to a positive terminal is +E while in the opposite direction -E irrespective of the direction of current in the circuit.



(iii) Also, where three or more conductors meet, the algebraic sum of current into any junction is zero.
Since current is the flow of electrons through a conductor, it cannot build up at a junction, meaning that current is conserved: what comes in must come out. When therefore performing calculations, current flowing into and out of the junction typically have opposite signs. This allows Kirchhoff's Current Law to be restated as: the sum of current into a junction equals the sum of current out of the junction.



> In this example, the currents i_2 and i_3 are flowing into the junction, while i_1 and i_4 are flowing out of it. Kirchhoff's Junction Rule yields the following equation: $i_2 + i_3 = i_1 + i_4$. Kirchhoff's Law describes the distribution of voltages within a loop, or closed conducting path, of an electrical circuit. Specifically, Kirchhoff's Voltage Law states that: ***the algebraic sum of the voltage (potential) differences in any loop must equal zero***. The voltage differences include those associated with electromagnetic fields (emfs) and resistive elements, such as resistors, power sources (i.e. batteries) or devices (i.e. lamps, televisions, blenders, etc.) plugged into the circuit. This is because Kirchhoff's Voltage Law comes about because the electrostatic field within an electric circuit is a conservative force field.

Conclusion

Comparison of students' output in the pre-intervention exercises and after the implementation of the intervention, show that students' performance in basic electricity and magnetism before the intervention was low (see Tables 1and 2 and Fig. 2). Most of the responses students' provided in the pre-intervention exercise were not correct. With the intervention of regular classroom tests, students' performance became better (see Table 4, Fig. 2). Students actively participated in classroom activities especially in class discussions. Most of the answers students provided in class were related to the questions asked. Majority of the responses students provided were with explanations and most of the explanations students gave reflected understanding of concepts learnt within the week and also the previous weeks. Results from these fortnightly tests support the findings of McDaniel et al. (2007) who found out that students' performance in a web-based college course improved significantly at end of the semester when the students were quizzed frequently throughout the semester. Students' understanding in the concepts taught in the classroom was immense. Evaluation involves determining whether the theoretical effects of the intervention strategies were realized, and whether these effects relieved the problems (Baskerville, 1997). According to the criteria for success, it can be said that the intervention strategies were successful. It may therefore be concluded that regular classroom tests improve students' learning and understanding in electricity and magnetism, that is, in physics. Moreover it also motivates students to learn and retain what they have learnt.

Implications for optimizing classroom instruction

Subject to the limitations of the study, the findings of the study have direct implications for optimizing methods of learning and instruction. The results of the study indicate that the use of regular classroom tests improve students' learning and understanding of concepts in Physics. Provision of prompt and descriptive feedback on classroom tests motivates students to learn more. Therefore the study strongly suggests that students should be tested frequently. Cumulative assessments which involve frequent testing may be quite useful in promoting understanding of concepts. The class tests stimulate students to learn concepts in detail, details that would not otherwise be learned for an examination. Regular classroom tests make the students revise throughout the term instead of all at the end the term. Teachers should therefore embrace this method if they want to maximize students' output in their various course of study.

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Appendix A (Pre-intervention test)

SCB 243 Electricity and Magnetism I

February 23, 2006 DURATION: 1 Hour

INSTRUCTIONS: Answer **all** questions. Show clearly how you arrive at your answer.

1. Three charges are arranged in the form of an equilateral triangle as shown in Fig. 1,

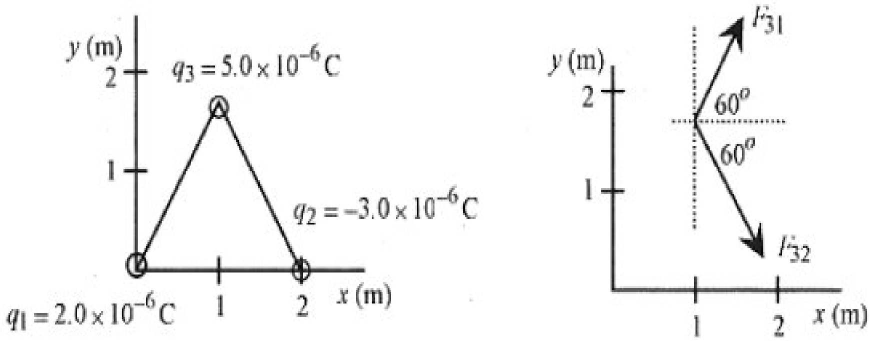


Fig. 1

Calculate the force on q_3 due to q_1 and q_2. (Answer: 0.0225 N)

2. The filament in a light bulb is a resistor in the form of a thin piece of wire. The wire becomes hot enough to emit light because of the current in it. The flashlight uses two 1.5-V batteries to provide a current of 0.40 A in the filament. Determine the resistance of the glowing filament. (Answer: R= 7.5Ω)

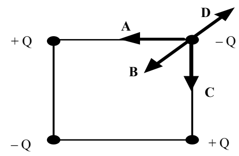
3. The instructions for an electric lawn mower suggest that a 20-gauge extension cord can be used for distances up to 35 m, but a thicker 16-gauge cord should be used for longer distances. The cross sectional area of a 20-gauge wire is $5.2x10^{-7}\Omega\cdot m$, while that of a 16-gauge wire is $13x10^{-7}\Omega\cdot m$. Determine the resistance of (a) 35 m of 20-gauge copper wire and (b) 75 m of 16-gauge
copper wire. (Answer: (a) 1.2 Ω; (b) 0.99 Ω)

4. A 6.00 Ω resistor and a 3.00 Ω resistor are connected in series with a 12.0 V battery. Assuming the battery contributes no resistance to the circuit, find (a) the current, (b) the power dissipated in each resistor, and (c) the total power delivered to the resistors by the battery. (Answer: (a) 1.33A; (b) 10.60W, 5.31W; (c) 15.9W)

Appendix C Fortnightly tests used in the intervention exercise

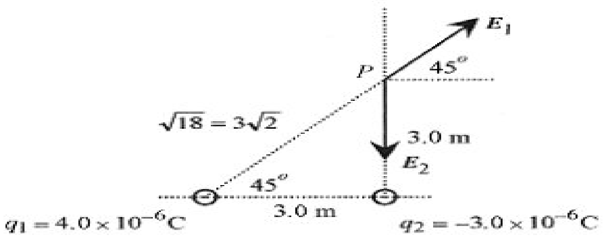
Test 1

1. Four point charges, each of the same magnitude, with varying signs are arranged at the corners of a square as shown below.



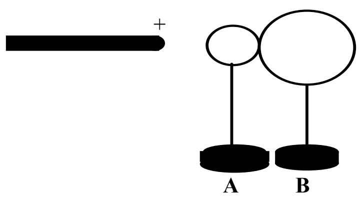
Which of the arrows labeled **A**, **B**, **C**, and **D** gives the correct direction of the net force that acts on the charge at the upper right corner? (Answer: **B**)

2. Calculate the electric field due to two charges, $q1 = 4.0 \times 10^{-6}$ C and $q2 = -3.0 \times 10^{-6}$ C, separated by 3.0 m and at a point 3.0 m opposite $q2$ as shown below.



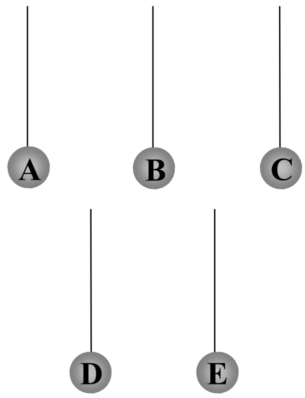
(Answer: ***E***R = (1.4 × 103***i***+-1.6 ×103***j***)N/C)

3 Two uncharged, conducting spheres, **A** and **B**, are held at rest on insulating stands and are in contact as shown blow.



A positively charged rod is brought near sphere **A** as suggested in the figure. While the rod is in place, someone moves sphere **B** away from **A**. How will the spheres be charged, *if at all*?
(Answer *Sphere* **A** *Sphere* **B**
negative **positive**)

4. Five styrofoam balls are suspended from insulating threads.



Several experiments are performed on the balls; and the following observations are made:

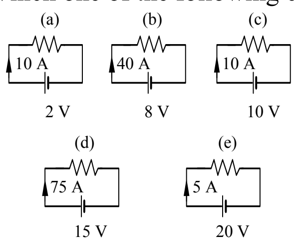
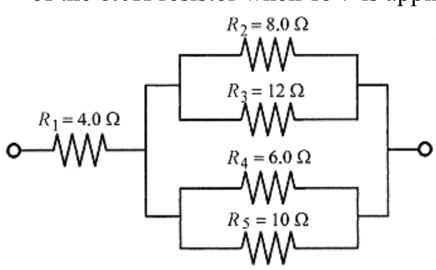
I. Ball A attracts B and A repels C.
II. Ball D attracts B and D has no effect on E.
III. A negatively charged rod attracts both A and E.

What are the charges, *if any*, on *each* ball?

(Answer:

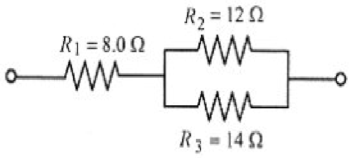
A	**B**	**C**	**D**	**E**
+	–	+	0	0)

Test 2

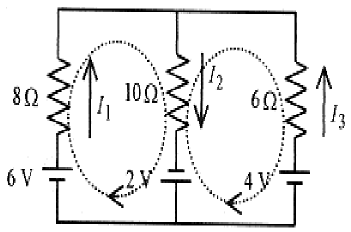
1. The resistivity of copper is 1.7×10^{-8} Ωm. What current flows through a 2.0m long copper conductor of 1.0×10^{-4} m^2 cross section when 20V is applied? (Answer: $5.9*10^4$ A)
2. (i) A 1000W electric heater operates at 115V. Calculate the current, resistance, and energy generated in one hour. (ii) If the voltage is reduced to 110V (assume no change in resistance) how does the heat output change? (Answer: (a) 8.7 A; 13.2Ω; $3.6*10^6$J. (b) 87 W)
3. Which one of the following circuits has the largest resistance?  (Answer: (**e**))
4. In the circuit below, calculate the voltage across, current through, and power requirements of the 8.0Ω resistor when 15V is applied to the network. (Answer: 5.16V; 2.46A; 3.3W. 

Test 3

<table>
<tr><td>Question</td></tr>
<tr><td>1. Calculate the equivalent resistance of the series-parallel combination shown in the figure below.



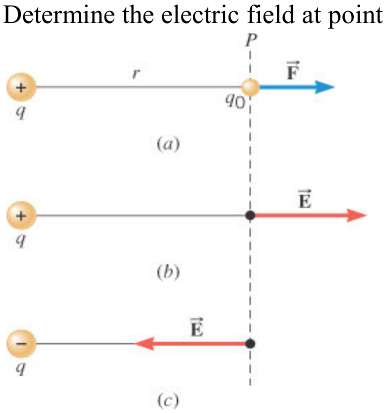
(Answer: 6.5Ω)</td></tr>
<tr><td>2. A capacitor with circular plates of 0.20m radius separated by 0.0010m is connected to a 100V battery. After a long time the battery is disconnected. What is the charge stored on the plates?
(Answer: 1.1 x 10^{-7}C)</td></tr>
<tr><td>3. Charge a 12μF capacitor with a 200V source, then place this capacitor in parallel with an uncharged 7.0μF capacitor and calculate the "new" voltage. (Answer: 126.0 V)</td></tr>
<tr><td>4. Solve for the current in each of the resistors in the circuit shown below.



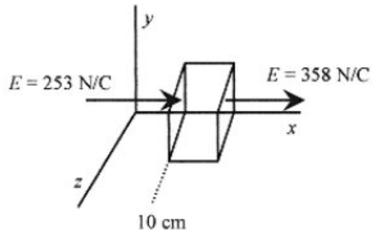
(Answer: *I1 = 17/47 = 0.36, I2=24/47 = 0.51, and I3=7/47=0.15*)</td></tr>
</table>

Test 4

<table>
<tr><td>Question</td></tr>
<tr><td>1. The isolated point charge of q=+15μC is in a vacuum. The test charge is 0.20m to the right and has a charge q_o=+15μC.
Determine the electric field at point P.



(Answer: 3.4×10^6 N/C)</td></tr>
<tr><td>2. Calculate the electric field vertically out from a uniformly charged disk of radius R and charge density
(charge/area) σ. (Answer: $\frac{\sigma}{2\varepsilon_0}$)</td></tr>
<tr><td>3. Calculate the sign and magnitude of the charge contained in a cube 10 cm on a side oriented as shown where the *E*-field is given by $E_x = (800 N/C \cdot m^{1/2})x^{1/2}$ $E_y = 0$ $E_z = 0$</td></tr>
</table>

 (Answer: 9.3 x10^{-12}C)
4. A positive charge is spread uniformly over the shell. Find the magnitude of the electric field at any point (a) outside the shell and (b) inside the shell. (Answer: (a) $E = \frac{q}{4\pi r^2 \varepsilon_o}$ (b) E = 0)

Test 5

Question
1. Calculate the capacitance of a cylindrical capacitor of inner radius *a,* outer radius *b,* and length *l.* (Answer: $C = \frac{2\pi \varepsilon_o l}{\ln(\frac{b}{a})}$)
2. The work done by the electric force as the test charge (+2.0x10^{-6}C) moves from A to B is +5.0x10^{-5}J. (a) Find the difference in EPE between these points. (b) Determine the potential difference between these points.(Answer: (a) -5.0×10^{-5} J ; (b) -25 V)
3. An electron placed between two charged parallel plates separated by 2.0×10^{-2}m is observed to accelerate at5.0×1014ms-^{2}. What is the voltage on the plates? (Answer: 25 V)

Test 6

Question
1. Calculate the deflection of the electrons in a typical video display tube due to the earth's magnetic field. [Take the electrons with 10KeV energy. Orient the tube north to south and with the electron beam at right angles to the earth's *B* field of 4.0×10^{-5} T]. (Answer: The electron is deflected in a horizontal plane)
2. An α-particle moves in a circle of radius 5.0×10^{-2} m in a magnetic field of **2.0 T**. Calculate the speed of the α-particle and the frequency and period of the motion. (Answer: 4.7x10^{-6} ms^{-1}; 1.5×10^{7} s^{-1}, 6.7×10^{-8} s)