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# Web-Based Homework Assignments for Introductory Physics Courses

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author NQ designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Authors AIA and STM executed and managed the study. All authors read and approved the final manuscript.*

***Research Article***

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## ABSTRACT

In this work, we investigated the use of online homework in teaching introductory physics courses at United Arab Emirates University. The online homework assignments were conducted by "mastering physics" course managing system. Students had unlimited time for each question within the due date. They also received hints and feedback to correct their answers. The average grade for all homework's for each student has been calculated and classified according to the time spent in solving the homework. The time spent spans over an interval of time 0-800 minutes, and a Gaussian distribution for the time interval was observed with a peak at 300-400 minutes. It showed that students spent short time got a homework grade below 60% of the total grade; on the other hand students spent longer time achieved grades above 60%. The results were found to be correlated with students' scores achieved in traditional written tests.

*Keywords: Online tests; e-learning; blackboard manager; web-based courses; mastering physics; general courses.*

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## 1. INTRODUCTION

Students' poor performance in introductory physics courses is known to be a global issue [1]. Many physics educators contributed towards resolving this observation by using new different teaching methods [2-4]. The use of new technologies has received the attention of educators to improve students' performance [5]. Advances in computer technology are transforming the methods of instruction to a web-based one [6]. Their effectiveness for the learners provides a new paradigm of research [7]. They are widely used in higher education in delivering the material and assessing students' learning. In United Arab Emirates University (UAEU), the new technologies such as laptop projects, blackboard course management, e-learning and many others involving various hardware and software products are in use [8]. It has been proven that combining lecturing with other teaching methods and technology helps students retain their interest and attention, which stimulate students for more participation, and emphasizes different learning styles [9,10]. Mastering physics is an emerging such medium which has been proven to facilitate problem-solving transfer through tutorial problems [11], which contains help in the form of requestable hints, descriptive text, and feedback. It tutors students individually while providing instructors with rich teaching diagnostics. Twice as many students were able to complete problems correctly in real-time compared to those problems that did not provide any help [12]. The students' homework performance using a web-based testing system and paper-based in introductory physics courses have been assessed and compared. The result showed that students' perceptions about the web-based homework system were positive, and it suggests that students were motivated to complete more homework using the web-based method [13,14]. The effect of web-based assessment on student achievement was conducted in conceptual tests, exams, and homework assignments [15]. It is found that the web-based homework scores were higher than that of the paper homework.

In this work, mastering physics homework managing system is used for online assignments of introductory physics courses at UAEU. We have investigated the impact of the time allowed for students to complete an online homework on their average score, and its correlation with students' performance in traditional written examinations.

## 2. THE STUDY

The data in this study involves 30 students taking the first introductory physics course (electricity and magnetisms) at UAEU. Each student has to open an account on a web-based tutorial homework system called mastering physics by using a pass code provided by Pearson publisher. Students were asked to work out an online homework assignment at the end of each chapter which allows students to practice solving problems on the basic physics concepts covered during the lectures. The homework includes multiple choice, fill in numbers, and essay questions.

When a student login to the assignment site, he/she will find several questions that were carefully selected by the course instructor from the site accompanies the textbook "University Physics" by Young and Freedman [16]. Questions were selected from the end of each chapter, test bank, and tutorial problems and questions. An example of the online homework is shown in the appendix at the end of this manuscript, and contains 4 problems to assess students' understanding in calculating the magnetic force on a moving charge in a magnetic field, and the force on a wire-carrying current in a magnetic field. Here, students are asked to complete the homework assignments outside the classroom and they can use the textbook or any other reference, since this activity is assessment for learning which based on thinking rather than memorizing. They might interact with each other; therefore, the learning process of individual student is affected. It is reported that plagiarisms is a very serious problem and it is the form of academic dishonesty that has significantly increased in the last 40 years [17]. Therefore, homework options and features in mastering physics allow restrictions in order to minimize students' plagiarism. In this work several restrictions were implemented:

- Limit the due date for submitting their assignments; about a week time was given for students to complete an online homework.
- Questions appear for students one at a time.
- The variables of a question were randomized.

After submitting the answers, students received feedback to correct their answers. The feedback includes hints on solving a problem correctly by breaking down the problem into steps. When students were satisfied and felt that they understood their mistakes and learnt how to answer the question or solve the problem correctly, they normally stopped receiving hints. Demanding more hints may affect the total score of the student. Since students' understanding is the center of the learning process, in this pilot trial of using mastering physics students were allowed to receive as many hints as they want without any reduction in their score. Moreover, the time for each homework assignment was left open in order to encourage students using the online homework which makes them feel more relax in doing their homework assignments.

To measure the effectiveness of online homework on students learning, the scores were correlated with students' performance in traditional tests. Herein, three written tests were scheduled during the semester, and each test covers the material of three chapters in the textbook. The tests were graded uniformly by teaching assistants in the department according to model solutions, and the scores were recorded. On the other hand online homework were automatically graded and recorded by mastering physics homework system.

## 3. RESULTS AND DISCUSSION

The homework was completed by 30 students distributed over two sections. Each student submitted eight online assignments through mastering physics homework managing system. The total time spent by a student in completing the eight assignments was calculated. The total times for students are distributed in the range from 71 to 723 minutes. The time scale is divided into eight groups, each of one hundred minutes. The number of students out of the sample in each group is plotted in Fig. 1.

The figure shows a normal Gaussian distribution of the time spent by students with a maximum number of students at 300-400 minutes group, where 37% of the students are belonging to this group. The number of students is decreasing at the sides of the maxima, where a very small number of students spent short-times (0-100 minutes) and long-times (700-800 minutes). Mastering physics course manager classifies the problems according to the progress of students who did these questions all around the globe, in terms of time and difficulty. It is interesting to note that the time of 300 minutes is the total average time spent by students all around the world who did the selected problems, and it agrees with our observation in Fig. 1 that the majority of students in this study spent about this time.

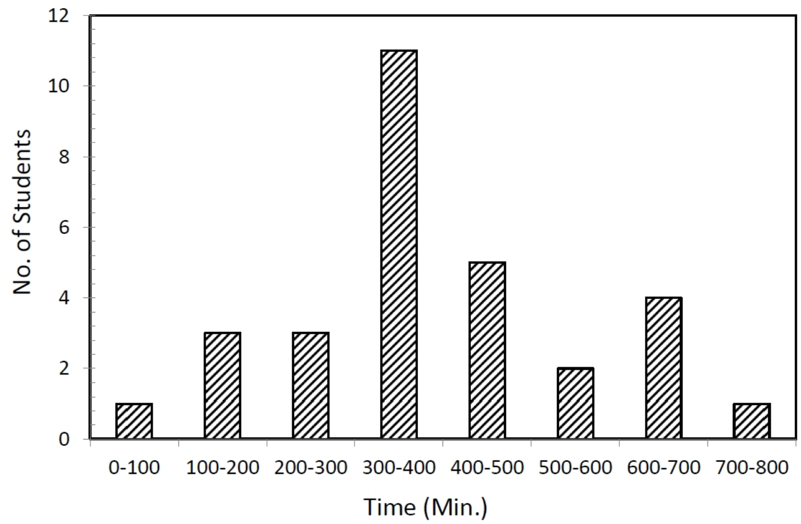


**Fig. 1. The number of students distributed over the eight time groups they spent in doing their homework**

Students' learning through assignments and tests are reflected by students' scores. The average score of the eight homework assignments were calculated and categorized according to the grading scheme shown in Table 1. Students in each time group were distributed over the grade categories according to their average homework score. Fig. 2 shows students' distribution over the time groups, and the figure displays that students' performance in the time groups 0-100 and 100-200 is very low where no students scored more than 60% of the total score. In this group, students did not spend enough time on doing their homework and did not show interest in completing it successfully. On the other hand, all students who spent longer time between 600-700 minutes showed better performance, where none of them scored less than 60% of the total homework score. Those students are distributed over the grade categories: one student scored between 60-69, one student between 70-79, and two students in the category 90-100.

**Table 1. Online homework grading scheme and the number of students in each category**

| Grades Category | Number of students in each group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0-100 min** | **100-200 min** | **200-300 min** | **300-400 min** | **400-500 min** | **500-600 min** | **600-700 min** | **700-800 min** |
| 90 – 100 | 0 | 0 | 2 | 6 | 2 | 0 | 2 | 0 |
| 80 – 89 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 70 – 79 | 0 | 0 | 0 | 2 | 2 | 1 | 1 | 0 |
| 60 – 69 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 50 – 59 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 40 – 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 – 39 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 – 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 – 19 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

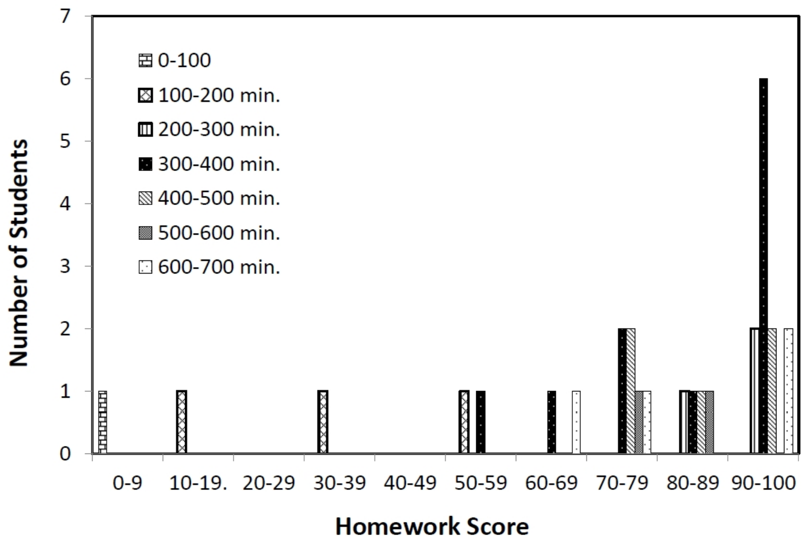


**Fig. 2. The distribution of students over grade categories for each time group**

Between these two extremes there are three students spent time between 200 to 300 minutes, where their performance is remarkable and their scores are between 80 -100. The other interesting group is 300-400 which consists of about 38% of the sample (11 students). 55% of the students in this category (6 students) scored more than 90, and other students are distributed over grades from 50 to 89. The time scale between 300-400 minutes could be considered as a standard time for the sincere and serious students for completing successfully the given eight online assignments.

The performance of students in the homework as observed in Fig. 2 is not absolute, because students may receive some external help; many students were motivated by a desire to pass the course and/or obtain a degree rather than to learn. The written tests in solving analytical problems can be considered a good measure for students' understanding, since students made and complete the tests in the class under the instructor invigilation. Therefore, the average scores of students in online homework were correlated with students' average grades in three written tests that cover the same homework material, as shown in Fig. 3. Each point in the figure represents the average score of one student. The score is calculated out of one hundred. The dashed line in the figure is the best straight line fit for the data with a slope equal to 0.75. A more realistic relationship between the online homework and average score of the tests can be found by calculating the correlation coefficient $r$ using [18]:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{(\sum X^2 - \frac{(\sum X)^2}{N})(\sum Y^2 - \frac{(\sum Y)^2}{N})}}$$

where X and Y are the correlated variables for homework and tests' average scores, respectively. The correlation coefficient of student's performance in Fig. 3 was found to be $r$ = 0.54, which indicates that the performance in online homework somehow reflects the actual academic level of students, as measured by the written-test scores. The data points in Fig. 3 are accumulated around the least square fit straight line, nevertheless there are points scattered away on both sides towards either high or low homework performance. Students with low performance spent short period of time between 100-200 minutes in solving the problems. They are considered to be inactive during the semester, because they showed less interest and missed the opportunity to improve their skills through the online homework assignments and other activities. On the other hand, the offline high homework performance was achieved by students who might seek others' help or spent longer time to solve the homework problems.

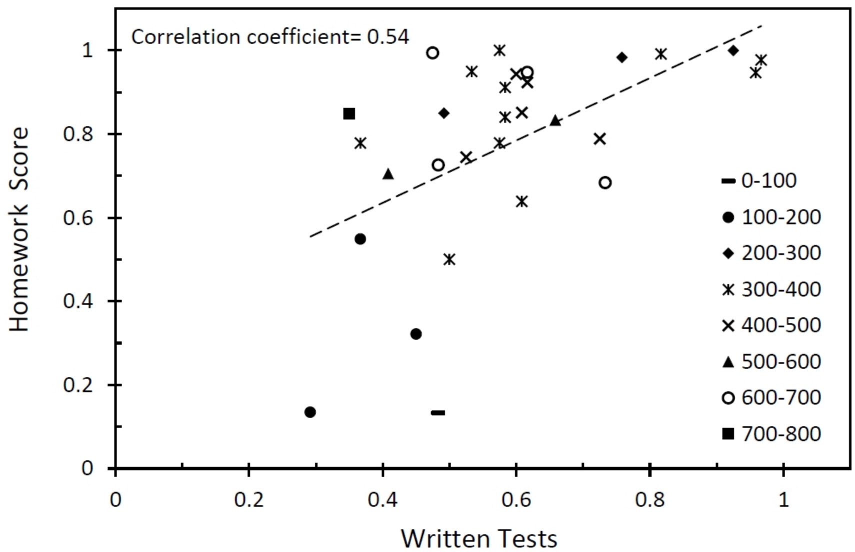


**Fig. 3. The average scores for students in online homework assignments versus written tests for all time groups in minutes. The data is normalized to the highest possible score. The dashed line is the least square fit for the data of all time groups**

Receiving external help (plagiarism) is a worldwide problem and its popularity among students deserves more consideration. Normally, students who spent a short period of time and they got a higher score in the homework than in the exams were most probably received an external help. Hence the percentage of students in each time group who gained higher average score in the homework than the trend line (straight line fit) of the data in Fig. 3 was calculated, and the percentage in each time group is plotted in Fig. 4. The figure shows that 25% of the students who spent short time (100-200 min.) in solving their homework most probably did not ask for an external help, due to their low scores. It seems that those students have minimal motivation to improve their learning. The percentage of students who achieved better performance in the homework increased with time; and it reaches 80% for students who spent 600-700 minutes in solving their homework. Those students either have received an external help or they had sufficient time to do their assignment correctly. In the group 300-400, there are 11 students, 6 of them (55%) achieved high homework score. Among the 11 students there are 3 students (27%) scored above 80 in the tests. It is remarkable that 200-300 minutes was sufficient to complete the online homework successfully, and 2/3 of the students in that group achieved above 80 in the written tests. This may conclude that the time 300-400 minutes is more than enough to complete the online assignments, and about 50% of the students in the time group 300-400 are most likely received an external help in doing their homework. Note that adding the number of students that might have received external help in doing their homework for all time groups and divided by the total number of students in the sample, it gives about 50%. It is remarkable that this value is in good agreement with the percentage of students normally passed the final exams in general physics courses at UAEU. This is not characterizing UAEU students only, but also students in other places [19]. The absence of external help factor in the written tests suggests that students who did not practice solving homework problems were not be able to manage the time of the written tests. Consequently, the overall fraction of students passed the written tests is similar to that of the online homework assignments.

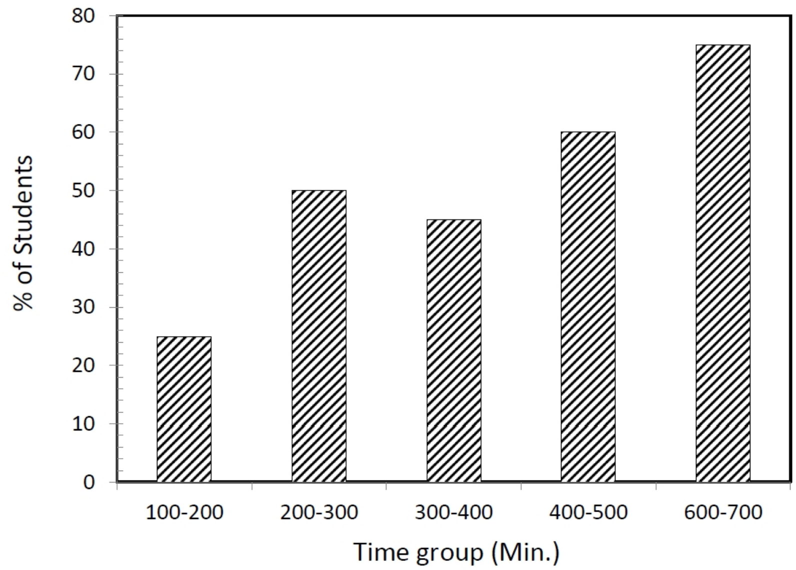


**Fig. 4. The percentage of students in each time group who achieved better performance in the homework than the exams**

Moreover, it is a general habit of students to start working on their homework just prior to the due time. Therefore, they feel under pressure and have to complete and submit their homework. Thus, they exert much less effort and did not learn the analytical skills in solving the problems which were targeted by the homework [10]. Consequently, students' performance in the exams is strongly correlated with their seriousness in doing their homework.

Nevertheless, it is notable that using online homework increases the interaction of honest students during the semester; we noticed that the online tests had a considerable effect on students learning and achievements. Students felt that they can manage their scores and they were given the opportunity to enhance self-learning through hints on demand. Knowing that they can improve their scores, students became more responsible and displayed a very positive interaction among students and with their instructor.

## 4. CONCLUSION

The effect of time spent in solving online homework problems on the students' performance has been investigated. The total time spent by a student in completing 8 homework assignments was calculated. The data for all students is found to be distributed between 71 to 723 minutes. The analysis showed that:

- The majority of students spent 200-400 minutes, and the time found to be sufficient to complete the homework assignments.
- The fraction of students in each time group with higher homework score than tests is increasing with increasing the time duration.
- About 50% of the students in the sample might either had received an external help to do the online homework or they managed to do it during a longer period of time.
- The results display a reasonable connection between the students' performance in solving the homework and the written tests with a correlation coefficient of $r = 0.54$.

It is recommended to consider more time restrictions for the online homework duration and due date to allow students practice on managing the time of the tests.

## ACKNOWLEDGEMENT

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## APPENDIX

### Exercise 27.1

A particle with a charge of $-1.4\times10^{-8}\ C$ is moving with instantaneous velocity $\vec{v}=(4.80\mathrm{m/s})\,\hat{i}+(-3.20\mathrm{m/s})\,\hat{j}$.

**Part A**

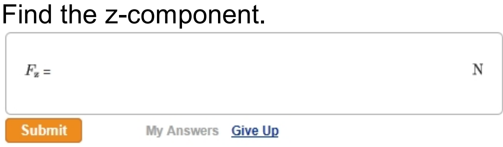
What is the force exerted on this particle by a magnetic field $\vec{B}=(1.60T)\hat{i}$ ? Find the x-component.


**Part B**

Find the y-component.

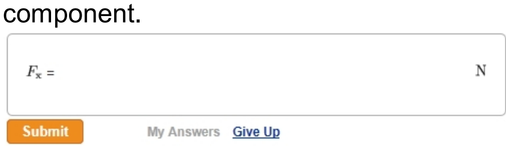

**Part C**

Find the z-component.



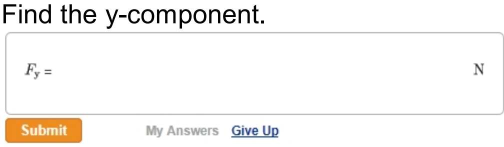

**Part D**

What is the force exerted on this particle by a magnetic field $\vec{B}=(1.60T)\hat{k}$ ? Find the x-component.



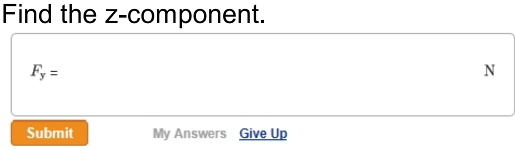

**Part E**

Find the y-component.




**Part F**

Find the z-component.

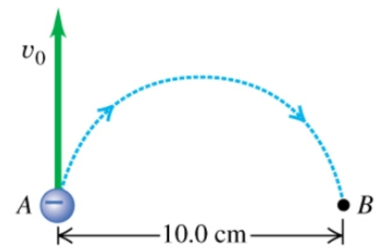


## Exercise 27.15

An electron at point A in the figure (Fig. 1) has a speed of $1.2 \times 10^6\ m/s$.

### Part A

Find the magnitude of the magnetic field that will cause the electron to follow the semicircular path from A to B.




$B$ = T

Submit My Answers Give Up

### Part B

Find the direction of the magnetic field that will cause the electron to follow the semicircular path from A to B.

- out of the page
- into the page

Submit My Answers Give Up

### Part C

Find the time required for the electron to move from A to B.

$t$ = s

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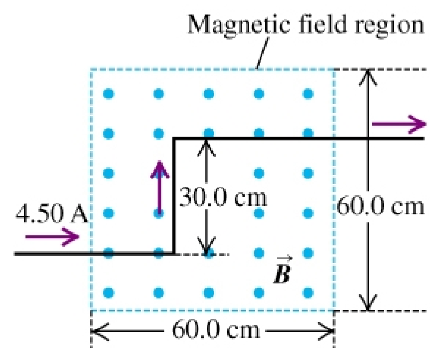
## Exercise 27.35

A long wire carrying 4.50 A of current makes two 90º bends, as shown in the figure. The bent part of the wire passes through a uniform 0.240 T magnetic field directed as shown in the figure and confined to a limited region of space.




### Part A

Find the magnitude of the force that the magnetic field exerts on the wire.

$F$ = N

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**Part B**

Find the direction of the force that the magnetic field exerts on the wire.

$\phi$ = ° clockwise from right direction

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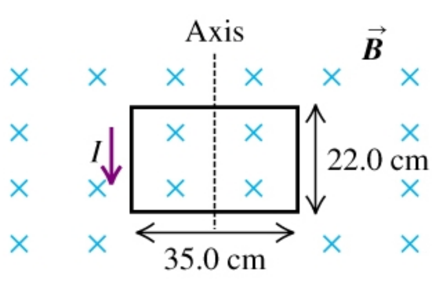
**Exercise 27.44**

A rectangular coil of wire, 22.0 cm by 35.0 cm and carrying a current of 1.40 A , is oriented with the plane of its loop perpendicular to a uniform 1.50 T magnetic field, as shown in the figure.




**Part A**

Calculate the net force which the magnetic field exerts on the coil.

$F$ = N

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**Part B**

Calculate the torque which the magnetic field exerts on the coil.

$\tau$ = N · m

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**Part C**

The coil is rotated through a 30.0 angle about the axis shown, the left side coming out of the plane of the figure and the right side going into the plane. Calculate the net force which the magnetic field now exerts on the coil. (Hint: In order to help visualize this 3-dimensional problem, make a careful drawing of the coil when viewed along the rotation axis.)

$F$ = N

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