**Phys 100 On–Line & On Campus**

**Forman Christian College**

**Physics 100 (BA/BS Hons.): SYLLABUS – ‘2021Fall On–Line’**

**This course meets the Bachelor of Arts and Bachelor of Sciences degree requirements.**

**Course Prerequisites:**

 This course is **NOT** recommended for students who have passed physics in Intermediate or A–levels or equivalent. Knowledge of elementary mathematics/pre–calculus is preferable.

**Professor:** Dr. Laila Zafar Kahlon

**Email:** **lailakahlon@fccollege.edu.pk**

**Cell/WhatsApp:** – [03314151670] (**emergency** use only – send an SMS before calling)

**Class meeting Time:**

|  |  |  |  |
| --- | --- | --- | --- |
| Sec | Lessons | Lab | e–mail /Office |
| **E** | 1 contact hour each**T, R****9:30-10:45** (S029) | Two contact hours**R**11-12:50 (S039) | **S–025 Armacost Science Block**042–9231581–88ext:596**lailakahlon@fccollege.edu.pk** |
| Contact Hours | **M, W, F**12:00–1:00  |

**Availability outside Office Hours: –** By appointment only (send an e–mail or text message)

**Goals:**

 Introduction to physics lays emphasis on basic concepts that can be treated with elementary mathematics. These include applications of physics in everyday life to which the student can relate with.

**Laboratory:**

 Familiarisation with measuring instruments and related experimentation.

**Course content:**

 Introduction to physics, lays emphasis on basic concepts that can be treated with elementary mathematics (knowledge of calculus .is preferable but not essential)

 These include applications of physics in everyday life to which the student can relate with.

 Concepts to be taken up are: Scope of Physics, Communications, Basic Electricity, Kinematics and bodies in motion or Medical Physics or Elements of Astrophysics

 This course is designed to provide students with a working knowledge of the elementary physics principles mentioned above, as well as their applications, and to enhance their conceptual understanding of physical laws.

**Evaluation:**

 Course evaluation is based on a blend of regular homework/assignment sets and/or quizzes, reports from the lab/activity period, midterm and final exam quiz and other evaluative tools. This course meets the Bachelor of Arts and Bachelor of Sciences Honours degree requirements.

**Duration:**

 One 13 – 16–week semester (6 weeks in summer) including examinations and preparation time.

**Contact time:**

 Three contact–hour lessons of theory and one two–contact hour lesson of laboratory work per week.

# **Learning Outcomes:**

By the end of this course it is hoped that students will be able to:

1. Understand and appreciate that most of the natural phenomena can be explained using fundamental laws of physics.
2. Develop understanding of the material studied by solving applicable problems.
3. Become familiar with physics principles applicable in other fields of science.
4. Become familiar with the techniques used in measurement and measuring instruments.

**Note:**

* Work in this Course is Set and Graded CONTINUOUSLY: Thus, to excel in this Course, you need to engage in sustained hard work. To gain maximum benefit you should lookup material **before** Classes.

|  |  |
| --- | --- |
| **Credits:** | Total |
| Theory/ Lab | Attendance/Participation | **10** |
| Tests/Quiz/ Assignments  | * Minimum 3 Quiz/Assignments
 | **35** |
| **Mid–Term Test/Exam** | **20** |
| **Final Examination** | 20% Lab Exam80% Final ExamPractical Notebook counted as 1 assignment at end of course | **45** |
| **Total** |  | **100** |

**Gradable Course Work comprises:**

* A minimum of 6 – 8 pieces of Class work, which are likely to be in the form of 20 – 50–minute quiz of either TF/MCQ or – questions or a combination, one being the midterm and the last being the final exam.
* All examination, tests and assignments shall be **CUMULATIVE*, i.e. may or may not contain material from previous assignments and tests.***

**Homework:**

* 2 pieces of Homework, which are likely to be in the form of 2 papers of questions from the text. The solutions to Homework may be reached independently or collaboratively (your choice). However, ALL Homework MUST be written up in your OWN words (see section below on **Academic Honesty**). As already mentioned, Homework assignments can be done in teams, but all team members **MUST** turn in an individual set of homework solutions neatly written or typed (not via e–mail).
* A set of Lab work, which involves your participation within and writing up of about 10 – 12 sessions of laboratory experiments. **Laboratory Notebook**:

**Setting and Marking of Gradable Work:**

 Each piece of Gradable Work is set within ONE WEEK of time indicated on the syllabus. The rules by which marks are allocated are identified each time a piece of Gradable Work is set. You will achieve maximum marks if you:

**A) Demonstrate excellence in the following Learning Outcomes:**

Thorough appreciation of the Course Content

* Understanding of how to use basic concepts and fundamental laws of physics to explain natural phenomena and apply the knowledge to solve numerical problems.
* Ability to use basic measuring instruments for the purposes of experimentation.
* Utilise, AS A MATTER OF ROUTINE, correct handling practices relating to physical quantities and data.
* Ability to self–learn criticise and report.

**B) Demonstrate excellence in the following aptitudes:**

* Use of the medium of English
* Legible writing, neat drawing, and neat calculations and graphing.
* You MUST bring into each Lab, or class, where appropriate, your OWN calculator to perform and check calculations.

**Materials List Required:**

**A NON–GRAPHING scientific calculator is required**. Use of calculators on cell phones, PDA’s, etc. is not permitted. Graph paper and graphing tools (pencil, eraser, ruler etc.)

**Note:** It is **NOT** permitted for you to share items during Gradable Class work.

 Since the experiments which will be performed by the class comprise the core of the course, **attendance is mandatory**, and will be recorded. Students must organize their work or [Laboratory Worksheets in a Folder](http://instructor.physics.lsa.umich.edu/106/courseinfo_lorenzon.html#Laboratory Notebook:#Laboratory Notebook:) (to be graded independently of other assignments).

**Required Work:**

* Attend ALL classes. Arrive on time and stay the entire period.
* Perform all laboratory work and submit all homework assignments on time.
* Take the quizzes and both exams.
* Explore, be attentive, interact – pose questions to me or to each other and figure things out.

**Note:**

1. An assignment/quiz will be posted/given to the class fortnightly on the average (see syllabus below).

2. The Notebook/Lab Worksheets will be collected weekly.

3. Absences will be approved ONLY in the case of extenuating circumstances. Non–approved absences will quickly erode your course grade.

4. **Note that this Syllabus does NOT provide for makeup exams, re–sits, rescheduling and/or extensions.**

5. You can bring only a one A4 page of notes to the two examination and no other references.

6. Bring your own calculators to quizzes and exams – **MOBILE PHONES CANNOT SUBSTITUTE CALCULATORS**

**Midterm and Final exam**

 The exams will be given according to the university schedule, with questions similar to the quizzes in format.

**Required Text:**

 **Physics in Context**, W. J. Zealney, M. Hynoski et al, Oxford University Press (ISBN: 0 19 550776 2) [2 vol. set] 2002

**Optional Text:**

 **Fundamentals of Physics** Extended version, David Halliday, Robert Resnick and Walker, Jerel, (7th Edition) John Wiley & Sons, 2002

 **University Physics with Modern Physics**, Hugh D. Young, Roger A. Freedman, (eleventh edition) (ISBN 81–297–0464–1) Pearson Education Ltd. [LPE] Addison–Wesley, 2004

 **Physics for Scientists and Engineers**; Paul A. Tipler; W. H. Freeman & Company, 6th Edition, 2007

**Syllabus**

|  |  |  |  |
| --- | --- | --- | --- |
| **Weeks** | **Chapter** | **Topics** |  |
| **1 – 2** | **Introduction and Breadth of Physics** | **Vol I** chapter 1 | Quiz/Assignment |
| **3 – 5** | **Communication Physics** | **Vol I** chapter 2 | Quiz/Assignment |
| **6 – 8** | **Elements of electricity** | **Vol I** chapter 3 | Quiz/Assignment |
| **8** | **Mid Term Examination** |
| **9 – 10** | **Elements of electricity** | **Vol I** chapter 3 | Quiz/Assignment |
| **11 – 15** | **(One of the following)****Motion and kinetics/****Astrophysics/****Medical Physics****Revision** | **Vol I** chapter 4 /**Vol I** chapter 5 /**Vol II** chapter 4 | Quiz/Assignment |
|  | **Final Examination** |  |

**Attendance and Participation:**

 In line with the University’s expectation of % attendance, this Course rewards attendance and participation. Your Instructor will maintain a full record of Class and Lab attendance. Your 10 Attendance Credits are progressively reduced towards 0 if you Miss Classes. Missing Classes poses other dangers; for example, you may miss a piece of Class work, or a Homework deadline. Missed Class works and Homework, or a piece of Lab work means you get no Credits for that piece of work, but there are also penalties for attending, but NOT fully participating.

**Academic dishonesty, including plagiarism:**

 FCC does NOT allow activities, and acts stated above, to ensure that honest students are not disadvantaged. I will be vigilant of offences. I REQUIRE you to use your OWN words when answering questions in pieces of Class work. If, you HAVE committed **Academic dishonesty, including plagiarism**, you will be penalised as described in the Baccalaureate Student Handbook. But honesty is infinitely preferable to losing letter grades or failing. Thus:

* During graded work only allowing you to have at your desk, any Items provided by me (E.g. Question Paper, blank paper etc.).
* Not allowing you to have at your desk all other UNNECESSARY Items. These include (but are not limited to) BAGS, NOTES and **MOBILE PHONES**. All such UNNECESSARY Items MUST be switched off and placed in your bags or left with the instructor at the front of the class.
* Requiring you to sit in seats of MY choice.
* Not allowing all forms of communication (verbal, written, electronic etc.) – The only exception is that you may raise your hand if you need my attention.
* Requiring you to complete all washroom activities IN ADVANCE.

 The penalty for breaking these rules depends on its severity. Use of a mobile phone during a quiz, for example, results in (ZERO) marks for that piece of work AND you will be required to leave the room. In other cases, you may first receive a warning.

**Concessions:**

* Days when lab is held, are also counted as Attendance days.
* Homework and Gradable written work will ONLY be accepted if EITHER given to me OR posted under my Office Door by the **end of the working day of the deadline**. Late homework will NOT be accepted unless it is accompanied by proof of an extenuating circumstance.
* If Gradable Work is MISSED for unplanned reasons, concessions may be given, but ONLY in EXCEPTIONAL circumstances – e.g. DOCTOR’S NOTE indicating serious illness, but other reasons may be accepted at the discretion of the instructor.

## **Minimum Technical Skills:**

 As University students are expected to demonstrate competency in Computer Technology. To be successful in this course, you will need the following technical skills:

* Use electronic mail with attachments.
* Access and use the University LMS (Moodle and EMPOWER) and embedded software (Big Blue Button)
* Save files in commonly used word processing formats.
* Copy and paste text, graphics or hyperlinks.
* Open and access PDF files.

**Lab PHYS 100:**

**Experiments (Actual ones if changed shall be notified):**

1 Laboratory practices safety and other instructions

2 measurement of a volume of a cuboid/ prism/ sphere, using a Vernier calliper

3 Measurement of the volume of a sphere/piece of wire using a micrometre screw gauge

4 Verify the law of mass and the law of amplitude for a simple pendulum

5 Verify the law of lengths for a simple pendulum

6 Find the critical angle of a glass prism and hence find its refractive index

7 Verify that intensity of light and distance have an inverse square relationship

8 Learn the essential workings of the AC/DC laboratory kit and use of a electric measuring instruments i.e. a voltmeter/ammeter/Multimeter etc.

9 Measure current and resistance in a circuit and verifying Ohm’s Law

10 Measure the resistance of resistors in series

11 Measure the resistance of resistors in parallel

12 Measure the resistance of resistors in combination of series and parallel

## **Evaluation of the Course:**

 Students will be provided an opportunity to evaluate instruction in this course using the University's standard procedures, which are administered online by the Office of Institutional Research and Quality Assurance Cell (QEC) in the two weeks before the Finals.

 Additional informal formative surveys may also be administered, by me, within the course as an optional evaluation tool.

**Guide to Participating in This Course**

1. **Structure of this Course**
	1. The course is subdivided in Units – each lasting roughly a week plus time for exams and revision.
	2. You will be taking this course as part of a class of up to 35 other Participants. The Teacher would be the Facilitator.
	3. The course in 2020SP is being offered online and apart from timed lectures and laboratory instruction, most of the communication will be asynchronous, that is, participants might be communicating on the same topic at different times.

This is happening because the participants are not on campus and not online at the same time.

1. **Process**
	1. All participants in a class will go through the units, doing the units one at a time.
	2. In each of the Units, you will have some textual material to read, instructional material to watch and some exercises to do, problems to solve, usually something to think about and write.

There would be meeting times on “Big Blue Button” (Moodle) or “Zoom meeting” or “Microsoft Teams”.

* + - Some of these exercises will be documents you will be asked to post to the course website for assessment purposes.
		- You and the other participants in your Class should plan to read and give feedback on each of the items that are posted on Moodle or sent to you via e–mail for this course.
1. **What You Will Get Out Of Completing This Course**
	1. When you have completed this course, you will have accomplished the following:

You will have learned to:

* + 1. Understand and appreciate that most of the natural phenomena can be explained using fundamental laws of physics.
		2. Develop an understanding of the material studied by solving applicable problems.
		3. Become familiar with physics principles applicable in other fields of science.
		4. Become familiar with the techniques used in measurement and measuring instruments.

**To Succeed In This course, What You Need To Do?**

1. Be ready to spend 2–3 hours each week on this course, other than on–line meeting time.
2. Be on–time when you are instructed to post your work.
3. Have a back–up plan for how to access the Internet if you have trouble with your own computer.
4. When posting on the forum with the class and other participants, be respectful and courteous.
5. **What You Can Expect from me**
	1. I, as the Teacher, will make every effort to reply to any specific question within 48 hours of when I receive it.
	2. If I cannot get on the Internet for an extended period, e.g., 3 or more days, I will inform all participants in my class (e.g. via email or posting on Moodle).
	3. I will treat all participants with respect. If you feel I am not doing this, please let me know what I am doing that you find disrespectful and I will change that if I can.
	4. I will do everything I can think of to make this learning experience fun, enjoyable, and enlightening
6. **Technical Issues**
	1. To participate in this course online, you will need access to the following software and hardware:

Please make sure that your computer meets these requirements. It is important to use supported internet browsers (Microsoft Edge, Google Chrome or Firefox) while using “Moodle” or “Zoom” or “Microsoft Teams” to ensure a successful experience.

|  |  |
| --- | --- |
|   | **Fully Supported Browsers**  |
| **WINDOWS** | Internet Explorer or Microsoft EdgeFirefoxGoogle Chrome |
| **Android Mobile****iPhone tm** | MoodleTm APP including Big Blue Button Tm (works but not recommended for attempting quiz on–line where WiFi is not assured) |

For the most part, you will only need to be able to do the following:

* 1. Go to and use the Moodle LMS and related software for the course material and attempting quiz.
	2. Open documents in *Microsoft Word, Excel* or *Adobe Acrobat Reader* (PDF).
	3. Send messages and documents
	4. Receive or Attach documents in your official FCC email.
	5. Go to other websites on the Internet.

**Introduction**

 The primary purpose of this introduction is to help prepare you for this structured program in introductory physics.

**The Program of Study**

When you take this course, here is what you will be doing. Here is the sequence of the scheme:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Content** | **Learning Objectives** | **Online methods and resources** | **Assessment** |
| Week 1 to 4 | Students develop understanding about the need of an experimentally validated scientific method and a measurement system of Units (SI system) | Listed in detail weekly plan | Moodle uploaded PowerPoint and also sent via e–mail to students who already have reference text with themLinks to on–line resources | Quiz on Moodle/campus |
| Week 5 –8 | Students develop understanding about Wave motion, reflection and Refraction of Waves | Listed in detail weekly plan | Moodle uploaded PowerPoint and also sent via e–mail to students who already have reference text with themLinks to on–line resources | Assignment on questions from textbook supplemented with some from other textbooksQuiz on Moodle/ campus |
| **Mid Term Examination**  | Quizzes on Moodle/ campus or written exam (if possible) |
| Week 9 – 12 | Sources of Energy, Basics of Electricity – Current, Voltage, circuits with one power source etc. | Listed in detail weekly plan | Moodle uploaded PowerPoint and also sent via e–mail to students who already have reference text with themLinks to on–line resources | Assignment on questions from textbook supplemented with some from other textbooksQuiz on Moodle/ campus |
| Week 12 + | Medical Physics or Motion and kinetics / Revision | Listed in detail weekly plan | Moodle uploaded PowerPoint and also sent via e–mail to students who already have reference text with themLinks to on–line resources | Assignment on questions from textbook supplemented with some from other textbooksPresentation |
| **Final** |  |  |  | Quizzes on Moodle or written exam (if possible) |

**Lab Work** – Demonstration of Experiments (if feasible) otherwise link to online experiments that are opensource relating to content and questions concerning the experiments (plotting graphs and extrapolating data – even if physical measurement is not possible) - use of online simulator software.

|  |  |  |  |
| --- | --- | --- | --- |
| **Week** | **Learning Outcomes** | **Methods and Resources**  | **Assessment** |
| **Week 1 and 2**  | **Week 1 and 2 – Introduction and Breadth of Physics** | This consists of on campus and video lecture from the resource set (downloadable) Power point presentations and discussions.  | A Quiz would culminate this segment. |
|  | You would learn about the Scientific Method andrecognise the role played by physics as a fundamental science identify the relevance of physics to modern society.analyse the roles of observation, measurement, recording and theory in the process of scientific investigationrecognise the need to test theory against observationsrecognise physical laws as concise statements about how nature is observed to function.recognise the nature of fundamental quantities and the need for standardised units of measurement (System International)appreciate the range of masses, length and time intervals commonly found in our Universe review the use of exponential notation and prefixes in expressing observational data. discuss about measurement and uncertainties in measurement. Be able to convert measurements made in non–standard units to SI units.recognise the necessity for valid and reliable datarecognise that repeated measurements show a spread or uncertainty about an average or mean valuecalculate absolute and relative errors of measurementcompare results within their uncertainties. | <https://ocw.vu.edu.pk/Videos.aspx?cat=Humanities+Distribution&course=GSC101> (lectures 1, 2,) |  |
| **Lab 1 and 2:**  | Introductory Laboratory practices and measurement;  | Vernier callipers and Micrometre (<https://www.youtube.com/watch?v=XQT6RSNN9sA>)  | Lab Reports |
| **Week 3 to 5 – Communication Physics** | You would learn todescribe the energy transformations describe waves as a transfer of energy disturbance that may occur in one, two or three dimensions, depending on the nature of the wave and the mediumidentify that mechanical waves require a medium for propagation whereas electromagnetic waves do notdefine and apply the following terms to the wave model: medium, displacement, amplitude, period, compression, rarefaction, crest, trough, transverse waves, longitudinal waves, frequency, wavelength, velocitydescribe the relationship between particle motion and the direction of energy propagation in transverse and longitudinal wavesquantify the relationship between velocity, frequency and wavelength for a wave: v = fλidentify that sound waves are vibrations or oscillations of particles in a medium.explain an echo as a reflection of a sound wavedescribe the principle of superposition and compare the resulting waves with the original waves.describe electromagnetic waves in terms of their speed in space and their lack of requirement of a medium for propagation identify the electromagnetic wavebands, especially Radio, Microwave, Visible, UV, X–rays and gamma rayidentify methods for the detection of wavebands in the electromagnetic spectrumexplain that the relationship between the intensity of electromagnetic radiation and distance from a source is an example of the inverse square law: $I∝\frac{1}{d^{2}}$ | This consists of video lecture from the resource set (downloadable) Power point presentations and discussions<https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html> | . One or more Quiz would be administered weekly and would culminate this segment |
| **Lab 3, 4** | (Inverse square Law – Intensity decreases as square of resistance **Periodic Motion – Laws of pendulum** | <https://www.youtube.com/watch?v=y2gNj6whIMk>) <https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html> | Lab Reports |

|  |  |  |  |
| --- | --- | --- | --- |
| **Week 6 to 9 –** | You would learn todiscuss how the main sources of domestic energy have changed over timeassess some of the impacts of changes in, and increased access to, sources of energy for a communitydiscuss some of the ways in which electricity can be provided in remote locationsdiscuss the environmental impact of certain sources that are used to generate electricity (renewable and non–renewable sources of energy)describe the behaviour of electrostatic charges and the properties of the fields associated with themdefine the unit of electric charge as the coulombdefine the electric field as a field of force with a field strength equal to the force per unit charge at that point, E = F/qdefine electric current as the rate at which charge flows (coulombs/second or amperes) under the influence of an electric field | **Elements of electricity** This consists of video lecture from the resource set (downloadable) Power point presentations and discussions | One or two Quiz and Mid-Term Test would culminate this segment. |

|  |  |  |  |
| --- | --- | --- | --- |
| **Week 6 to 9 – Cont** | identify that current can be either direct with the net flow of charge carriers moving in onedirection, or alternating with the charge carriers moving backwards and forwards periodicallydescribe electric potential difference (voltage) between two points as the change in potential energy per unit charge moving from one point to the other (joules/coulomb or volts)discuss how potential difference changes at different points around a DC circuitidentify the difference between conductors and insulatorsdefine resistance as the ratio of voltage to current for a particular conductor R= V/Idescribe qualitatively how each of the following affects the movement of electricity through a conductorlengthcross–sectional areatemperaturematerial.**Students shall also learn to:**identify the difference between series and parallel circuitscompare parallel and series circuits in terms of voltage across components and current through themidentify uses of ammeters and voltmeters.explain why ammeters and voltmeters are connected differently in a circuitexplain why there are different circuits for lighting, heating, and other appliances in a houseexplain that power is the rate at which energy is transformed from one form to anotheridentify the relationship between power, potential difference and currentidentify that the total amount of energy used depends on the length of time the current is flowing and can be calculated using energy = V x l x texplain why the kilowatt–hour is used to measure electrical energy consumption rather than the joule. | This consists of video lecture from the resource set (downloadable) Power point presentations and discussions | One or two Quiz would culminate this segment. |

|  |  |  |  |
| --- | --- | --- | --- |
| **Lab** | **Required: On–line circuit Lab (You might have to create a free account)**  | **Lab – manual available on Moodle – for download**Lab Experiments on electrical circuits using the on–line circuit simulator [https://phet.colorado.edu/sims/html/circuit–construction–kit–dc–virtual–lab/latest/circuit–construction–kit–dc–virtual–lab\_en.html](https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_en.html) | Lab Reports |
|  |  |  |  |
| **Week 10–14** | **Moving about (Motion and kinetics)** |  |  |
|  | You would learn toidentify that a typical journey involves speed changesdistinguish between the instantaneous and average speed of vehicles and other bodiesdistinguish between scalar and vector quantities in equationscompare instantaneous and average speed with instantaneous and average velocitydefine average velocity as displacement divided by time.define and work in reference frames differentiate and represent scalar and vector quantitiesbe able to plot and extract data from position–time, velocity–time and similar graphs.solve problems involving uniform accelerated motion.Solve problems using vector manipulation – head to tail rule and/or trigonometric methods to resolve vectors into components and add and subtract vectors.describe the motion of one body relative to anotheridentify the usefulness of using vector diagrams to help in solving problemsexplain the need for a net external force to act in order to change the velocity of an objectdescribe the actions that must be taken for a vehicle to change direction, speed up and slow downdescribe the typical effects of external forces on bodies including friction between surfaces and air resistance (calculations of friction coefficient are omitted)define average acceleration as the change of velocity over timedefine the terms ‘mass’ and ‘weight’ with reference to the effects of gravityoutline the forces involved in causing a change in the velocity of a vehicle when: coasting with no pressure on the accelerator, pressing on the accelerator, pressing on the brakes, passing over an icy patch on the road, climbing and descending hills; following a curve in the road.interpret Newton’s Second Law of Motion and relate it to the equation: **F = ma**identify the net force in a wide variety of situations involving modes of transport and explain theconsequences of the application of that net force in terms of Newton’s Second Law of Motion.define momentum as: p = mvdefine impulse as the product of force and timeexplain why momentum is conserved in collisions in terms of Newton’s Third Law of Motion.Solve problems of conservation of momentum for collisions – problems requiring coefficient of restitution are not required to be done. | <https://ocw.vu.edu.pk/Videos.aspx?cat=Humanities+Distribution&course=GSC101> (lectures 1, 2, 3, 5, 6 7, 8, and 9) | One or more Quiz and Final Cumulative Exam/ project would culminate this segment. |
| **Lab** | **Vector manipulation** | https://phet.colorado.edu/sims/html/vector-addition/latest/vector-addition\_en.html  | Lab Reports |
| **Week 15 –** | **Revision** | **Week 15 – Revision** |  |