Syllabus for Advanced Laboratory (PHY 544 – CRN: 4373, Section 201)
Spring 2023 Science Building, Room 180A – (M & F: 1-3 pm)

Course Description: This is a 2-credit hour laboratory style class. Students will perform hands-on laboratory experiments that are designed to be completed at the pace of 1 experiment every 2 to 3 weeks (or 4-6 class periods, or 8 to 12 hours per experiment). These labs in most cases will be set-up from scratch by students, building skills not typically found in undergraduate laboratories where labs might be already set-up for students upon their arrival. Each lab will require addressing questions presented in the instructions with those answers reported in a required lab report for each lab. The brief lab reports will not exceed 3 single sided pages total (or 1.5 pages double sided). From the 2022-2023 course catalog: "Developments in producing and detecting correlated photon pairs has enabled implementation of undergraduate laboratories demonstrating fundamental quantum mechanical principles. This laboratory also incorporates fundamental solid state and materials science experiments."

Textbook: None required. Custom in-house instructions will be provided for most labs. The following text books are good starting point references to dive deeper into the material. (1) and (2) are for the solid state and materials science experiments and (3) is for the correlated photon experiments. The two photon labs will be based off experiments presented in (3).

(1) Introduction to Solid State Physics. Charles Kittel, 1996. John Wiley and Sons, Inc.
(2) The Physics and Chemistry of Materials. Joel I. Gersten and Fredrick W. Smith, 2001. John Wiley and Son, Inc.
(3) Beck, M. (2012). Quantum mechanics: theory and experiment. Oxford University Press.

Pre/Co-requisite Courses: PR: PHY 525 and PHY 542, or
CR: PHY 525 and PHY 542

Course Instructor Info: Dr. Sean P. McBride**,** Science Building 152/152A,
(304)-696-2758/8852, mcbrides@marshall.edu
'HERD Hours' and Office Hours: (**F** 8-10 am & **F** 11-1 pm and **F** 3-5 pm)
- Additionally, I have an 'open-door' policy for office hours as well as an 'email me anytime with questions' policy.

Teaching Homepage: http://www.science.marshall.edu/mcbrides/teaching/
Research Homepage: http://science.marshall.edu/mcbrides/

Academic Calendar: For drop/add dates, last day to withdraw from classes, and other important semester dates, see the Marshall University Academic Calendar (http://www.marshall.edu/academic-calendar/).

Objectives: During the first ~1/2 of this course, students will set up and run some classic laboratory experiments that may have eluded students in their previous undergraduate laboratories. These experiments are focused on looking at the Seebeck effect, the Hall effect, Dia-, Para-, and Ferro-magnetism, superconductivity, and Young's Modulus. At the surface, some of these experiments will be rather simple, but the underlying mechanisms at work leading to the observations students will see can be quite complex. In the last half of the course, students will work with 2 labs revolving around correlated photons. The lab instructions for each lab provides a brief history of the experiments and their founder along with some information guiding you through the observations students will encounter and the set-up for each lab. The manuals for each piece of equiptment used for each experiment are stored in a 3-ring binder specific to each lab with the instructions. This physical 3 ring binder should not leave the lab room. All these documents will be made available to students in advance of the labs in Blackboard, so they can be read and reviewed prior to coming to lab.

For Graduate Students Only: Students will be required to either (1) develop a new lab from start to finish, including writing an instruction guide with questions and answers and complete trial runs of the lab in the current semester or (2) revise an existing lab to make it better for the next generation of students (i.e. dive deeper into the underlying physics and develop different/additional content than what is presented currently in the instruction manual to stimulate the next generation of students who complete the lab (develop new question and answers). Through either of these options students will hopefully gain a deeper understanding of the material for the lab they are designing or revising (diving deeper into).

Attendance: I view all university level students as adults, who can or must do adult things, such as drive a car, vote, pay taxes, and who can also be sentenced to jail as an adult. Thus, as adults, I expect you to be responsible and be in lab at all scheduled meeting times; however, you will not be docked points if you have an emergency. Notify me immediately when you realize a conflict exists so we can come up with an alternative plan. All labs need to be completed for a grade otherwise an 'Incomplete' will be recorded.

Learning Outcomes: In the process of carrying out the laboratory experiments as described above, **the overarching goal**, is for students to work and function together in a team, become confident in setting up experiments effectively from scratch with help from the provided instructions, communicate what they have done and observed through brief but high quality concise lab reports, and to be able to visualize & better understand some physics concepts that might have been taught in their undergraduate classes (but never directly witnessed or recorded data for). In order to accomplish this goal successfully, students will be given **practice** via conducting weekly labs with a partner and writing laboratory reports for those labs. Students' individual success in achieving this goal will be **assessed** by their individual performance on those lab reports. New labs will typically start on Fridays, the exception being the first lab, which starts on Monday the first week. The two-week labs span four 2-hour time slots, starting Friday and Finishing Monday. The same structure will exist for the three-week labs, spanning six 2-hour time slots, starting Friday and Finishing Monday There are no exams for the lab course.

Lab Reports: Lab reports are ideally due after completing one lab and starting the next; however, Monday to Friday may not be enough time to complete the lab reports, especially with all your other responsibilities; thus, you will have approximately 10 days after completing the lab to turn in your brief concise detailed lab report, See schedule. Your brief concise detailed lab report, should be just that, brief and concise. The font should be Arial 10 or new times roman 11 and the document should be single spaced with 1-inch margins all the way around. The brief lab write up will not exceed 3 pages total (1.5 pages double sided). The lab report must include all required plots and answers to the questions asked in the instructions Sometimes writing such a condensed document and getting all the information in that is required is harder than writing a longer document. Journal articles have word limits, so this is good practice for students.

Your completed laboratory report packet should include all questions from the instruction packet answered and all requested plots and data processing/analysis completed and included in your report. Don't turn your plots in separate, include them in your lab report. Format them to make them fit in the 1.5-page limit and make them readable, no unreadable font sizes. The reports should include your findings, observations, and a discussion of the physics involved related to what you observed in the lab. **Reports should include a brief Abstract, Introduction, Results and Discussion section, and a Conclusion section.** Excel can be used to plot data. Treat these lab reports as mini journal article submissions. They should look professional. You should not be agonizing over the reports or spending excessive amounts of time on them. If you are not sure how to construct such a report come see me. Before turning in your labs to be graded, I encourage you to come talk to me about if the format of your lab report is correct. I can offer suggestions and you can fix before turning the final version. One of the benefits of the lab course is you will gain some experience with scientific writing experience and presenting your data as figures, which are both needed for journal submissions. Labs will be graded for completeness (addressing all questions from instructions) and how successful students are at communicating what was accomplished through the four main parts of the reports discussed below.

In the one paragraph **Abstract**, concisely state the objective of the experiment, how you meet that objective, what your results were, and did the results support the objective (most of the time these are numerical values to report, but in some cases not). Provide a very brief **Introduction** to lab with the underlying physics and history (include references). In the **Results and Discussion** section be specific, discuss the set-up, discuss errors, discuss how the results support or do not support the objective. Discuss what you learned. Include your plots here (label axes with meaningful names, provide units, provide brief figure captions). Comment on how the data presented in the graphs proves or does not prove the objective of the experiment. Answer the question from the instructions here. As you do experiments try to visualize where errors could arise and how these errors contributed to your results. Evaluating your data and results in an effort to understand whether the results are meaningful is a valuable part of experimental science, and often a very difficult part. Discuss these errors in the results and discussion section, this should be part of every lab. The **Conclusion** for every experiment should make a statement about what you have achieved and learned by doing the experiment, what results you have obtained, how the experiment and data supports the involved physics laws, concepts, and principles. The labs are designed to be completed in the allotted time, but if your group is running short on time during the lab for whatever reason, you can finish the lab during other times during the week, we just have to work out times. **Reference** section should go at the end.

Grading: Each lab completed will carry an equal weight of your total grade (100% Total)

Determination of Final Grade:

90% or above:	A
80% or above:	B
70% or above:	C
60% or above:	D
59.9% or lower:	F

Spring 2023 Schedule:

Week	Lab	Name	Day	Report Due	Date
1	1	Seebeck Effect	M	-	9-Jan
			F	-	13-Jan
2			M	-	16-Jan
	2	Young's Modulus	F	-	20-Jan
3			M	-	23-Jan
			F	Lab 1	27-Jan
4			M	-	30-Jan
	3	Superconductivity and Magnetism	F	-	3-Feb
5			M	-	6-Feb
			F	Lab 2	10-Feb
6			M	-	13-Feb
	4	Hall Effect	F	-	17-Feb
7			M	-	20-Feb
			F	Lab 3	24-Feb
8			M	-	27-Feb
	5	Spontaneous Parametric Down conversion (A 3-Wave Mixing in Nonlinear Optics technique used to create entangled photons)	F	-	3-Mar
9			M	-	6-Mar
			F	Lab 4	10-Mar
Spring Break			M		13-Mar
			F		17-Mar
10			M	-	20-Mar
			F	-	24-Mar
11			M	-	27-Mar
	6	Proof of the Existence of Photons (the Grangier Experiment)	F	-	31-Mar
12			M	-	3-Apr
			F	Lab 5	7-Apr
13			M	-	10-Apr
			F	-	14-Apr
14			M	-	17-Apr
	-	-	F	-	21-Apr
Finals Week	-	-	M	-	24-Apr
	-	-	F	Lab 6	28-Apr

University Policies: By having the privilege of being enrolled in higher education and thus this course, you agree to all the University Policies and Codes listed in the below link. It is the student's responsibility to read the full text of each policy and code by going to http://www.marshall.edu/academic-affairs/policies/. The individual policies and codes are: Academic Dishonesty Policy, Academic Dismissal Policy, Academic Forgiveness Policy, Academic Probation and Suspension Policy, Affirmative Action Policy, Pre-Finals Week Policy, D/F Repeat Rule, Excused Absences, Inclement Weather Policy, Sexual Harassment Policy, Students with Disabilities, University Computing Services Acceptable Use Policy, and the Code of Student Rights and Responsibilities - also referred to as the Student Code of Conduct (https://www.marshall.edu/student-affairs/files/Student-Rights-and-Resp-2020.pdf).

Campus Services: There are many Campus Services & Resources that you or someone you know throughout your college career may find useful or desperately need at some point. The above link provides contact information for the Counseling Center (304-696-3111) and Health Services, Services for Students in Financial Need, Tutoring Services, and a wide variety of other services and resources (there are many services within each of these categories - check them out now so you know what is available to students). Chances are a version of this syllabus will always be posted on my Teaching Homepage if you ever need this information, even well after the class is over.

Statement Regarding Students Requiring Special Accommodations & Students with Disabilities: For University policies and the procedures for obtaining services, please go to MU Academic Affairs website (http://www.marshall.edu/academic-affairs/policies/) and see information under "Students with Disabilities". In order to receive any academic accommodations, you must meet with the coordinator of the Office of Disability Services (students are required to provide official documentation of the disability). For help with setting up accommodations, contact the Office of Disability Services (ODS) in Prichard Hall 117 (304-696-2467). For more information, access the website for the Office of Disabled Student Services: http://www.marshall.edu/disabled. If no official documentation from the Office of Disabilities Services is given to the instructor, no accommodations can be made by the instructor. Paperwork must come from the Office of Disabilities, not the student. Trying to get the process for accommodations started the week before an exam will likely not work out for you, more time is needed. Again, before any type of accommodations can be given by instructors, the instructor must receive official documentation from the Office of Disabilities Services or the required program; therefore, take care of this **the first week of classes** (this is true for the H.E.L.P Center and the WV Autism Training Center as well).

COVID-19 Related Information for Spring 2023 - Marshall's official COVID-19 protocols are online at https://www.marshall.edu/coronavirus. Policies and protocols may change over time as we respond to changing conditions. The website will always contain the most recent information – check it frequently for the most current information. The following is currently posted:

> "The Office of Environmental Health and Safety is announcing the following update regarding the COVID-19 response for the Spring 2023 semester.
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> Following the state of West Virginia's decision to end the State of Emergency for the COVID-19 pandemic, Marshall University has announced the closure of the on-campus COVID-19 clinic. COVID-19 testing and vaccines remain readily available at clinics and retail pharmacies throughout the area, including the Cabell-Huntington Health Department and Marshall Health clinics and pharmacy locations.
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> As the university transitions its response, the COVID19@marshall.edu e-mail will shift to an automated response providing the current COVID-19 guidance provided by the Centers for Disease Control and Prevention. The e-mail will continue to be monitored by the university's COVID-19 Response Team.
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> Marshall University employees should continue notify their immediate supervisors of a COVID-19 diagnosis for departmental guidance.
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> Students living in the residence halls who receive a positive COVID-19 diagnosis should contact the on-call area coordinator at 304-962-6559 to determine the best practice for isolation/quarantine. Any student needing an illness excuse should contact the Office of Student Affairs."