<table>
<thead>
<tr>
<th>New Course Code and Title</th>
<th>PAP 747 Spintronics for Information Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details of Course</td>
<td><strong>Summary of course</strong> <em>(please note that this information provided will also be uploaded to the web for viewing at large)</em></td>
</tr>
</tbody>
</table>

We are living in an era of information. Every second (as of 2015), 3000 Instagram photos are uploaded and 10000 tweets are sent and 50 hours of videos are uploaded in YouTube. Such activities generate lot of data and require huge amounts of processing. This would not be possible without tremendous progress in Magnetics and Electronics. Hard disk drives, based on Magnetics and Spintronics technologies, have grown 1000 fold in capacity in the past 2 decades. Similarly, the electronics industry has also grown.

This course will introduce magnetics and spintronics technologies which are useful in hard disk drives and the emerging magnetic random access. The course consists of three parts of almost equal lengths. The first part provides the fundamentals of magnetism. The second part discusses the basics and recent developments of magnetic recording. The third part discusses the basics and recent developments of magnetic random access memory. The course is suitable for students of Physics, Materials Science and Electrical Engineering (Microelectronics). The course is self-contained and there are no prerequisites.

| Rationale for introducing this course |

We are living in an era of information. Every second (as of 2015), 3000 Instagram photos are uploaded and 10000 tweets are sent and 50 hours of videos are uploaded in YouTube. Such activities generate lot of data and require huge amounts of processing. This would not be possible without tremendous progress in Magnetics and Electronics. Hard disk drives, based on Magnetics and Spintronics technologies, have grown 1000 fold in capacity in the past 2 decades. Similarly, the electronics industry has also grown. The growth is expected to continue for at least one decade in magnetic recording and for the next several decades in Spintronics. There are companies such as Seagate (5000 staff), Showa Denko (400 staff), Western Digital (200 staff), GlobalFoundries (7000 staff), Micron (7000 staff) which are working on magnetic recording and magnetic random access memory technologies. They regularly require researchers and students who are trained in this field. NTU does not train people in this area, which puts NTU students at a disadvantage as compared to the students from the other universities where such courses are available.

This course will benefit students in increasing the chances of getting hired in the magnetics/spintronics industry. From the economic perspective of Singapore, courses such as this will generate a pool of manpower required for companies that, together, employ about 20000 staff. This will help them to be routed here or to expand their activities in Singapore.
### Aims and objectives

The course aims to introduce the fundamentals and advances in the field of spintronics which advance storage and memory technologies based on magnetic principles. The objectives of this course are to

- Introduce the fundamentals of magnetism
- Introduce the fundamentals of magnetic recording and the recent advances
- Introduce the fundamentals of magnetic random access memory and the recent advances

### Syllabus

**Fundamentals of magnetism**

- Magnetism in Electrodynamics perspective
- Atomic magnetic moment
- Exchange interaction
- Ferromagnetic, ferromagnetic materials
- Antiferromagnetic materials
- Hysteresis loops
- Domains and domain wall motion
- Various types of anisotropies
- Hard and Soft magnetic materials

**Magnetic Recording Technology**

- Storage concepts
- Magnetoresistance (MR)
- Spin-valve sensors
- Magnetic recording medium
- Noise Reduction Techniques
- Layered configuration of medium
- Thermal Stability and Media Trilemma
- Emerging Recording Technologies

**Magnetic Random Access Memory**

- Overview of MRAM
- Various types of MRAM
- Spin-Torque Switching
- Challenges of MRAM
- Emerging Concepts

### Assessment

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<tr>
<th>Assessment</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Final Examination (individual-based)</td>
<td>50%</td>
</tr>
<tr>
<td>Participation, assignments and attendance (individual-based)</td>
<td>30%</td>
</tr>
<tr>
<td>Term Paper (individual-based)</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>100 %</strong></td>
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### Hours of Contact/Academic Units

52 hours / 4 AU