34029 project resume

Deadline: end of first month in 13-week period

The project resume is an initial overview of the project. It can be handed in as a one-page document, or as a (max) three minute long video “pitch”.

The purpose of the resume is to make sure that you have a clear agreement with your supervisor(s) on the project objectives, the methods that will be used to pursue these objectives and on the tentative time plan for the project. The project resume will be your guide throughout the project and it is important that you have discussed your project resume with your supervisor.

Use clear and well separated statements. The project resume must contain the following headlines:

Background and motivation:

- What is the background and overall objective of the project and why is it interesting? (the big picture).

Objectives:

- What are your objectives? Objectives should be stated so that they are *specific* and *measurable*, i.e., so that at the end of the project it can be checked whether the objectives were reached or not.

Tasks:

- Divide the project into a manageable (3-6) number of well-defined tasks/activities and make a bulleted or numbered list of the tasks. For each task, indicate what will be done and the key methods that will be used. These define the route that you will follow in the project to reach the objectives.

Time plan:

- Indicate the time plan for the tasks in a simple GANTT-like diagram. Do not forget to allocate time for data analysis and report writing (see example below).

An example of a written project resume is given on the next page.

Example of project resume:

Wavelength-dependent optomagnetic measurements

Background and motivation

There is a need for low-cost methods for the sensitive quantification of biomolecules, e.g., for diagnostics. An optomagnetic technique, which can sensitively measure the size of magnetic nanoparticles and nano-particle clusters in any transparent container, has been proposed to meet this goal. The technique measures the modulation in light transmitted through the nanoparticle suspension in response to an applied oscillating magnetic field as function of the frequency of the field. The light-nanoparticle interaction depends on the wavelength of the light and it is therefore interesting to investigate the wavelength dependence of the signal as a properly chosen wavelength may enable more sensitive biodetection.

Objectives

- Construct setups to enable optomagnetic (OM) measurements at a range of wavelengths between 400 nm and 900 nm.
- Measure OM spectra for suspensions of nanoparticles with diameters of 100 nm and 250 nm at a range of wavelengths between 400 nm and 900 nm.
- Identify optimum wavelengths for measurements of clustering of the studied magnetic nano-particle suspensions.

Tasks and time plan:

- Characterize and understand OM spectra in existing setups for wavelengths of 405 nm, 650 nm and 780 nm for suspensions of nanoparticles with nominal diameters of 100 nm and 250 nm (T1).
- Use laser machining to construct optomagnetic (OM) setup that can fit into an existing fluorometer with a continuously tunable wavelength of light and measure OM spectra of the two nanoparticle suspensions vs. wavelength (T2).
- Construct a setup add-on with a discrete set of wavelengths provided by up to 12 light emitting diodes, possibly with automated change between diodes, and measure OM spectra of the two nanoparticle suspensions vs. wavelength (T3).
- Analyze and compare measurements performed using the fluorometer and the LEDs as light source (T4).

Task	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
T1: OM measurements in existing setups	x				
T2: OM setup and measurements, fluorometer	x	x			
T3: OM setup and measurements, multi-LED		x	x		
T4: Analysis and benchmarking			x	x	x
Report writing		x	x		x

34029 project report

deadline: 2^{nd} week in 3-weeks period

Below we will give some general advice on the structure, formatting, and style of a scientific report that you can use as advice but also as a check list when you write your report.

Report structure:

A scientific report should be written so that others not only can understand what you have done but also are able to reproduce your work to, hopefully, obtain the same results as you. This forms the basis for the scientific approach and should be followed for your work to be valuable. It has also led to the following structure, which has become the norm in scientific reports (and papers)[1]:

Section	**Content**
Title	• Includes what was studied, how it was studied and the context in which it was studied. • Must be brief, concise and descriptive.
Abstract	• Provides a condensed and concentrated version of the full text (<1 page). • Uses this structure: Background/motivation → Objectives → Methods → Key results → Conclusion. • Can be understood without reading the paper/report.
Introduction (Chapter 1)	• Provides context (big picture, motivation for research). • Introduces previous research and background for project • Gives the objectives of the project. They should be specific and measurable (see project resume).
Methods	• Provides step-by-step details on how experiments were performed. • Should provide enough detail so that the experiments can be repeated. • Describes how you will analyze the raw data (for simple, known analyses). • Is written in the past tense. To find a good balance between detail and overview, imagine that you travel back in time and pass on this information to yourselves at the project start. Include the information needed for you to be able to recreate the results.
Results	• Presents and describes analyzed data. Advanced data analysis developed during project can be presented here. • Reports facts that can be observed (and reproduced) by anyone following *Methods*. Discuss also if data is well described by the applied models. • Also reports results of model fits and analyses. • Expresses the data appropriately in figures and tables.
Discussion	• Discusses whether the obtained data supports the hypothesis (are the applied models the correct ones?). • Explores the implications of your findings (interpretation and consequences) and potential limitations of your study. • Compares the results compare to what others have found • Discusses future work to be undertaken

[1] Based on http://www.writingcentre.uct.ac.za/sites/default/files/image_tool/images/167/Scientific%20Reports.pdf

Conclusion	• Clearly relates the obtained results to the project objectives (as stated in the introduction) and makes a conclusion. This may also include an outlook with suggestions for further work.
References	• Makes clear reference to any information not obtained by you. This also includes figures etc.
Appendices [if relevant]	• Show your raw data here in tables, graphs, etc. • Can also include detailed conditions, data, analyses, and derivations that supplement the methods and results. It should be possible to read the main text without reading the appendices.

There are many variations of this structure and often it takes a few iterations to find the structure that fits your project the best. For example, for a project that can be divided into two well-separated parts, it is often meaningful to have a joint "Results & Discussion" section with the format:

Results & discussion: Results #1; Discussion #1; Results #2; Discussion #2.

However, when you write it is important to make a clear distinction to the reader between *Methods* (what was done?), *Results* (what was measured? How do (given) models describe measurements?) and *Discussion* (meaning and implications of results, what have others done? How can models be improved?). Someone else following the same *Methods*, should obtain the same *Results*, but the *Discussion* may evolve over time as the understanding increases (and the initial Discussion or interpretation can turn out to be dead wrong, whereas the results stand). Note, that this structure does not mean that *Results* is just a long list of figures and uncommented results – you can and should analyze results to the extent possible in *Results*. Simply state clearly the models that are applied and on which assumptions they are based. However, leave the discussion of the validity of models and what the results mean in terms of models and their improvements to the *Discussion*.

Language:

- Read general brief advice on scientific writing in 'Elements of Style' by Griffies, S.M., Perrie, W.A., Hull, G. Can be found via link at end of document and is also uploaded to DTU Inside.
- A good place to look up words is https://www.merriam-webster.com/
- Use **simple wording** rather than trying to use fancy/"sciency" words as this will make the text easier to read (this is sometimes called plain or simple English).
- Avoid use of **"rubber" words** and subjective statements that are not precise, such as "the theory fits the measurements *reasonably well*". Instead relate objectively to the data and the analysis by comparing to the error bars. Can the theory describe the measurements and which quantitative measures do you base this on?
- Use **short and concise sentences** with only one point in each sentence and only one topic in each paragraph. If a sentence, phrase or word can be deleted without changing the meaning, the text will most often be better if it is deleted.
- The **apostrophe-forms** *don't*, *hasn't*, *it's* etc. used in spoken language do not belong in scientific text. Instead write *do not*, *has not*, *it is* etc.
- Three important rules in English grammar regarding **commas**:

   - When in doubt, leave it out.
   - Comma before the last element in a list, e.g., "this line of research combines physics, nanotechnology, and photonics." This is known as the Oxford Comma and is used by most scientific journals.
   - Pause comma: Use commas to denote natural pauses in a sentence, e.g., "despite the oxidation of the sample, we found a signal-to-noise ratio exceeding 100."
- Compound adjectives require a **dash**. It is particularly important when specifying something with numbers. For example, consider the difference between "single photon source" (an unspecified light source of which there is only one) and "single-photon source" (a quantum light source emitting photons one by one).

<u>Notation, variables, units and numbers:</u>

- In Danish, a comma is used as **decimal separator**. In English, a punctuation mark is used as decimal separator. For example, in English $\pi \approx 3.14$.
- All **variables** are always written in italic (*slanted*) font and are defined in words the first time they appear, e.g., "…where x is the distance traveled by the car". In LaTeX, use $ $ around variables, e.g. x – also in the body text.
- **Units** are always written in roman (upright) font. In LaTeX one of many ways to do this is to use $\mathrm{}$, e.g., $V=1~\mathrm{m^3}$. Always state the **units** of numbers! (unless they are dimensionless, of course). Use SI units (see links at end of document).
- **Functions** such as sin, cos, exp, tan should be written in roman font. In LaTeX, use $\cos$, etc.
- **Text subscripts and superscripts** and labels that are not variables should be written in roman font. In LaTeX, write x_{max} as x_max or $x_{\rm max}$.
- Always state **variable names and units** on axes in graphs and in tables. In tables, units can be given in square parenthesis after the header in the table, e.g. x [m], and then the values can be stated without unit in the table. This also goes for a prefix, e.g., x [10^{-4} m]. Note that this equivalently can be written as $10^4 x$ [m].
- Use **pre-fixes** to make values easier to read. For example, write 0.12 mV i stedet for 0.00012 V.
- **Uncertainties** are always stated with one, at most two, significant digits. Values are always stated so that the uncertainty is on the last one or two digits. Values with uncertainties can be stated in the following ways: (1) $x = 1.23\ \mathrm{m} \pm 0.02\ \mathrm{m}$, (2) $x = 1.23\pm0.02\ \mathrm{m}$, (3) $x = 1.23(2)\ \mathrm{m}$
  Normally, either form (2) or (3) is preferred. The unit can also include a prefix, e.g.,
  $x = (1.23 \pm 0.02)\times10^{-4}\ \mathrm{m}$ or $x = 123 \pm 2\ \mu\mathrm{m}$.
  Always state the value and its uncertainty in the same manner (using same prefix).
- If you want to **compare** measured parameters (with uncertainties) to results from fits (with uncertainties), it is often advantageous to report both results in a table.

<u>Uncertainties:</u>

- When you state values with uncertainties, it is important to state how you found the value and estimated the uncertainties. Typically, a simple way to find the experimental uncertainty is to measure the same quantity, e.g., five times and calculate the standard deviation (obviously this does not take systematic errors into account). It is not acceptable to just state "we estimate the uncertainty to…".

<u>Graphs/figures</u>

- Always number figures consecutively!
- The **figure caption** should clearly describe what is measured and for which sample it is measured (for figures reporting experimental data). It should be possible from the figure caption alone to work out what the figure reports (and without reading the body text). Therefore, include important parameters/conditions in the caption. For example "Measurements of position *x* vs. time *t* for…<write conditions for experiments. If many or there are several different conditions, then put them in a table and refer to the table>". The figure caption *should not* contain a description or discussion of observations or conclusions made from the figure – this belongs in the body text.
- If you have not prepared a figure yourself, make sure that you give a **proper reference** to the source of the figure. This should be done in the figure caption. Examples of text: "Figure is from [1]." (just copied figure), "Panel (a) was adapted from [1]." (example of part of figure adapted from a reference).
- If you show a picture, micrograph or a drawing, include a **scale bar**.
- Use a **font size**, which is sufficiently large to be read when the document is printed. As a rule of thumb, characters should not be smaller than 2 mm in the printed format.
- Use clear and concise **axis labels** with the same symbols as used in the text and indicate the unit in square or parentheses, e.g., "*x* [m]" or "*x* (m)". Whichever you choose, **be consistent**.
- Learn how to write **Greek symbols** and super-/subscript symbols in your plotting program.
- Use **prefixes** on units to avoid values with many zeros.
- If you show several curves in the same graph, include a **legend** in the graph (if possible) rather than explaining the legend in the figure caption.
- Graphs should not include **tables or results from fits**. These belong either in the caption, the body text or in a table. For example, if equation (1) is the expression for a straight line (constant velocity):

  $$x(t) = x_0 + v\,t \qquad (1),$$

  a caption could state on the fit: "The line is a fit of Eq. (1) to the data with x_0 = (0.10 ± 0.05) m and v = (10.0 ± 0.2) m/s (R^2 = 0.996)".
- **Several graphs** can be combined on a page using one of the following two ways:

  (1) Graphs that are **related** should have the same figure number but are given labels (a), (b), …. They have a common figure caption with specific referral to (a) and (b).

  (2) Graphs that are **unrelated** (but are put side-by-side to optimize space) should have separate

figure numbers and captions. This often leads to a more messy layout and should be avoided but it is better than breaking the page limit.

- Avoid making graphs with sub-captions!
- If you show a graph or a figure, you also need to present it and **refer to it** in the body text.
- Use the export feature of your favorite plotting program to make the figure files in **high resolution** (preferably vector format). Never make screen dumps! Remember that plots made in Maple, Matlab and other tools (which are usually not of good quality with default settings) still need to have proper axis labels, symbols, units etc.

More information and advice can be found in the general guidelines from journals given in the links at the end of the document. Note that journals (and supervisors) may have different styles and preferences.

To conclude this section, we provide two examples for inspiration. As an example of a figure that hardly any supervisor would accept, consider the following[2]:

[2] WheelieDealer Blog, March 18 (2018), http://wheeliedealer.weebly.com/blog/showboating-with-the-mini-east-beast-charts-featuring-avap (accessed Aug. 10, 2018).

In contrast, most readers and supervisors would rather appreciate the style used in the Nature family or journals, such as this[3] (and notice the unfortunate page break, which can be avoided using the figure environment in LaTeX):

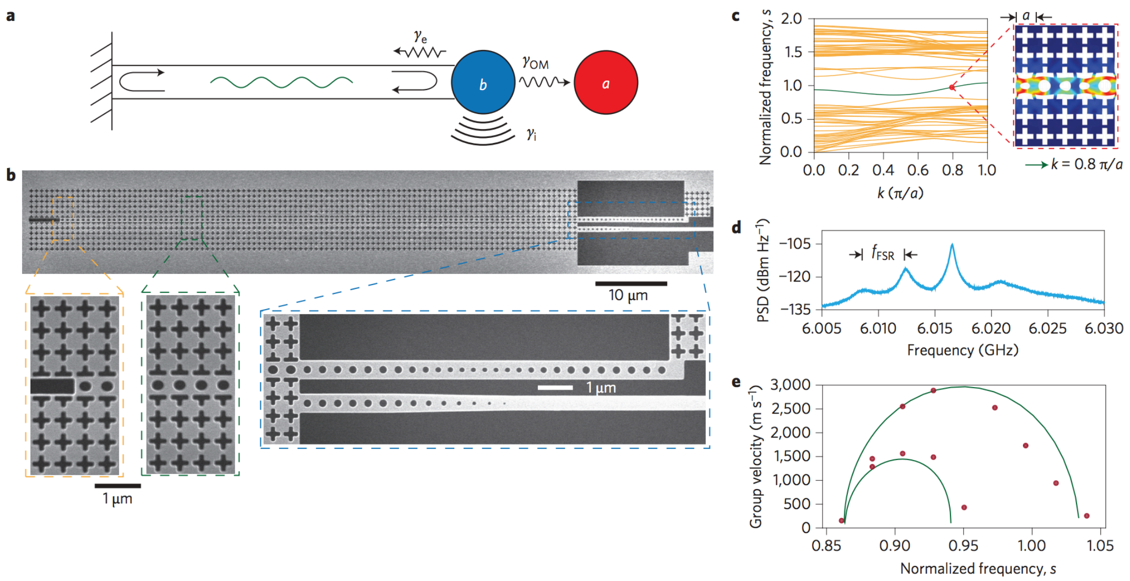

Figure 1 | Gigahertz dispersion-engineerable phonon waveguide. a, Schematic diagram of the single cavity-waveguide device (a and b represent the optical and mechanical cavity modes). The mechanical cavity mode couples to the phonon waveguide at rate γ_e and has an intrinsic decay rate γ_i and an optically induced decay rate γ_{OM}. **b**, SEM image of a silicon optomechanical cavity-waveguide device based on the scheme in **a**. The zoomed-in views show the nanobeam cavity and optical coupler, the phonon waveguide section and the waveguide termination, respectively. **c**, Theoretical bandstructure of the phonon waveguide used in this work. Green curve, waveguide breathing mode; yellow curves, bands of the phononic shielding. Inset (right): Modal profile of the waveguide breathing mode corresponding to wavevector $k = 0.8\pi/a$. **d**, Optically transduced mechanical power spectral density (PSD) of a typical device showing a few hybridized cavity-waveguide resonances. **e**, Group velocity as a function of frequency across the breathing mode waveguide band. Green, theoretical curve; red circles, measured data.

References:

When information is used from an external source, you need to make a proper reference to it. It will not be taken lightly if information, such as a figure found on the internet, is used without proper reference. This would be a breach of *good scientific conduct*.[4]

There are several correct ways (or "schools") on how to state and refer to references, where the specific choice depends on preferences of journals and supervisors. Below, we will just give examples of one possible way to report references. The most important part is that all relevant information is made available. If you use BibTeX with an appropriate BibTeX style (for example that from Physical Review) and provide all relevant information in the BibTeX file, this will be done automatically.

The term "*et al*." is an abbreviation for the Latin term "*et alii*" that means "and other people", which can be used when there are more than three authors (see example below). Generally, Latin terms are written in italic font.

[3] K. Fang, M. H. Matheny, X. Luan, and O. Painter, *Optical transduction and routing of microwave phonons in cavity-optomechanical circuits*, Nat. Photon. **10**, 489-497 (2016).

[4] http://www.dtu.dk/english/research/research-at-dtu/principles_for_good_scientific_conduct

Include all references as a list after the conclusion and avoid putting them in footnotes[5].

[5]unlike this document, hrm hrm.

Type	**Example of format**
Printed journal article	Format: <author 1: last name, initial(s)>,…, <author *n*: last name, initial(s) >. <paper title>. <*journal*> <**volume**>, <pages> (<year>) Example: Schott, D.H., Collins, R. N., Bretscher, A. Secretory vesicle transport velocity in living cells depends on the myosin V lever arm length. *J. Cell Biol.* **156**, 35-39 (2002).
Online journal article	Format: <author 1: last name, initial(s)>,…, <author *n*: last name, initial(s) >. <paper title>. <*journal*> <**volume**>, <article number>, <article doi> (<year>) Example: Bellin, D.L., *et al.* Electrochemical camera chip for simultaneous imaging of multiple metabolites in biofilms. *Nat. Commun.* **7**, 10535; 10.1038/ncomms10535 (2016).
Book	Format: <author(s) last name, initial(s)>,…, <author *n*: last name, initial(s) >. <book title>. (<publisher>, <year>) Example: Griffiths, D. Introduction to electrodynamics. (Upper Saddle River N.J: Prentice Hall, 1999)
Chapter in book	Format: <author (s): last name, initial(s)>, <chapter title> in <*book title*> (ed. <editor last name, initial(s)>) <pages> (<publisher>, <year>) Example: Smith, J. Syntax of referencing in *How to reference books* (ed. Smith, S.) 180-181 (Macmillan, 2013).
Thesis	Format: <author (s): last name, initial(s)>, <thesis title>. <thesis type (BSc, MSc, PhD)>, <place of thesis>, <year>, <web-link, if available> Example: Hansen, M.F. Magnetic properties of systems of magnetic nanoparticles. PhD thesis, Department of Physics, Technical University of Denmark, September 1998.
Web link	Format: <resource descriptor>, http://link (accessed <date, year>). Example: Wikipedia: Citing sources. https://en.wikipedia.org/wiki/Wikipedia:Citing_sources (accessed Jul 18, 2018).

Links:

- Introduction/overview to format of scientific reports and what goes in each section:
https://writing.wisc.edu/Handbook/SciRep/ScienceReport.html

- Good introduction/overview to format and writing style in journal articles:
http://www.publishingcampus.elsevier.com/websites/elsevier_publishingcampus/files/Skills%20training/Elements_of_Style.pdf (uploaded to DTU Inside)

- Another very good guide to scientific writing for journal publications:
https://www.nature.com/articles/nphys724

- National Institute of Standards (NIST) guide to SI units and formatting:
https://physics.nist.gov/cuu/Units/index.html (web-page with links and info)
https://physics.nist.gov/cuu/pdf/sp811.pdf (detailed 90-page guide)
https://physics.nist.gov/cuu/pdf/checklist.pdf (5-page checklist)

- Nature Scientific Reports style guide:
https://www.nature.com/srep/publish/guidelines

- American Chemical Society (ACS) style guide (very detailed!):
https://pubs.acs.org/isbn/9780841239999

- REVTeX package for LaTeX with template and style guide from the Physical Review journals (the author's guide contains much useful information on formatting):
https://journals.aps.org/revtex

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