University of South-Eastern Norway

EXAMINATION INFORMATION PAGE
Written examination

Subject code: **FM3217**	Subject name: **Object-oriented Modelling of Hydro Power Systems**	
Examination date: **2022-12-15**	Examination time from/to: **9:00 to 12:00**	Total hours: **3**
Responsible subject teacher: **Dietmar Winkler,** mobile: 46544524		
Campus: **Porsgrunn**	Faculty: **TNM**	
No. of assignments: **5**	No. of attachments: **0**	No. of pages incl. front page and attachments: **3**

Permitted aids:

- Writing and drawing tools
- Pocket calculator

Information regarding attachments:

Comments:

Select the type of examination paper

Spreadsheets [X] Line sheets [ ]

4 Electrical Grid (15%p)

4.1 General Questions

a) Write down the formula for the definition of droop (also known as regulation) R and explain all variables!
b) What does the power-frequency characteristic mean and how is it defined?

4.2 Calculations

Consider a situation where two generators are operating in parallel and each is feeding $50MW$ to the connected loads. Suddenly the frequency drops from $50Hz$ to $49.9Hz$. Both of the generators have droop control activated .
The generators have the following characteristics:

Generator 1

- $P_{n_1} = 150MW$
- $R_1 = 0.05$

Generator 2

- $P_{n_2} = 200MW$
- $R_2 = 0.03$

a) Calculate the production of each generator at the new lower frequency.
b) By how much did the total load **change**.
c) Propose one solution to raise the frequency back to $50Hz$ again.

5 Design of a Hydro Power System (10%p)

Design a Hydro Power System based on the following available data:
Level of head race: 600 m.a.s.l. (metre above sea level)
Level of tail race: 300 m.a.s.l.
Average flow rate: $1.79m^3/s$
Minimum flow rate: $< 0.9m^3/s$ for 20% of the year
Generator speed: $n = 750rpm$
The specific speed n_q and its relation to the speed number of a turbine can be calculated using the forumula:

$$n_q = \frac{n\sqrt{Q_n}}{\sqrt[4]{H_n^3}} =^* \underline{\Omega} \cdot 89$$

Based on that information please answer the following questions:

a) What maximum mechanical power can we expect to get out of a hydropower turbine assuming its maximum efficiency is $\eta = 0.95$. The losses of the waterway should be neglected.
b) What type of turbine would you choose?
c) Give a thorough explanation for the type of turbine you have chosen.