Grading guidelines for the FYS3415/FYS4415 final exam 2026

Grading is based on the solution key. The exam consists of three problems, with subtasks awarded points as follows:

Subtask	1a	1b	1c	1d	1e	2a	2b	2c	2d	2e	2f	3a	3b	3c	3d	**Total**
Points	6	7	7	7	8	5	4	6	6	7	7	7	8	8	7	**100**

All submissions are graded independently by two examiners. Each examiner assigns each subtask answer an integer number of points between 0 and the maximum value for that subtask. For any subtask where the examiners' scores differ substantially, typically by 2–3 points or more, the grading is discussed and the scores are revised as needed until no substantial difference remains. The final score is determined by taking the mean of the examiners' total scores. Grades are determined by applying the following grade boundaries to the unrounded mean score:

Minimum score	**Grade**
88	A
77	B
57	C
44	D
30	E
0	F

In general, answers should be justified. This applies in particular to questions using instructions such as "compute", "determine", "calculate", "find", or "show that", as well as to questions that explicitly ask students to "explain" or "justify your answer mathematically". Simply stating an answer with no explanation in such cases receives few points. On the other hand, full derivations are not required when the question uses instructions such as "write down" or "draw a circuit".

Some subtasks contain multiple questions. Unless stated otherwise below, no fixed point distribution is assigned to the individual questions within a subtask; instead, the score is based on an overall assessment of the answer to the whole subtask.

Correct solutions that differ from the solution key receive full credit, provided that they are correctly derived where required. Methods that are incorrect but accidentally give the correct answer in the end receive no points, although partial points may be awarded according to how much relevant understanding the method demonstrates.

When an answer is not fully correct or complete, partial credit is awarded based on academic judgment. Minor algebraic mistakes only lead to a small deduction, typically 1 point. A somewhat larger deduction, for example 2 points, may be appropriate if the error is easy to check and should have been noticed by the student. No additional points are deducted for errors that follow logically from an earlier mistake, unless that mistake makes a later task significantly easier. Conversely, if an earlier mistake makes a later calculation significantly harder and the student is unable to complete it correctly, some points may still be awarded. In both of these cases, points are awarded based on an overall judgment of how much of the intended understanding is demonstrated.

Additional comments on individual subtasks

1a Simply using the formula for pure-state fidelity given on the formula sheet is sufficient for full credit. 1 point is deducted for giving the squared value 1/2.

1b For the first question, answers such as "quantum bit" or "electron" are not sufficient on their own. To receive full credit for the second question, the answer must mention or indicate all four criteria in the solution key, including some mention of coherence, sufficiently low noise or error rates, or error correction.

1c The result must be clearly demonstrated, and simply restating the identity gives no points for the first question. Expressions containing "$- \oplus f(x)$" are penalized. Mentioning a correct algorithm is worth approximately 2 points.

1d This subtask is graded relatively generously. Still, full credit requires a short explanation of both Bell inequalities and DI-QKD, without conflating the two, and at least one relevant assumption for DI-QKD.

1e Verifying that the operators are positive semidefinite is not required for full credit.

2c 1–2 points are awarded for the correct answer itself. The remaining points are awarded for demonstrating mathematically why this is the answer. Any correct method for establishing that the state is entangled is accepted, including partial trace, rank of the coefficient matrix, a direct proof, or similar.

2d Approximately 3 points are awarded for a correctly derived reduced density matrix, and approximately 3 points for the accompanying explanation.

2e Approximately 2 points are awarded for the correct classifications, and the remaining points are awarded for justifying them mathematically. For the entanglement classification of σ_2, demonstrating that it is not entangled is sufficient for full credit; the word "separable" is not required.

2f The inverse preparation circuit is one valid answer, but any unitary circuit that works is allowed. Providing a correct circuit and a short argument indicating why the probability differs is sufficient for full credit. A full derivation of the measurement probabilities for the two density matrices is not required. Good derivations without a circuit receive a high score, but not full credit. Answers claiming that no such circuit exists receive 0–1 points.

3a For full credit, most of the steps must be mentioned with some short explanation, either in words or using a diagram, and a correct circuit for U must be drawn or clearly specified.

3b Full credit requires finding Kraus operators and determining p, not just deriving the channel. Any valid Kraus representation of the same bit-flip channel receives full credit. Checking that the Kraus operators satisfy the completeness relation is not required for full credit.

3c Credit is awarded roughly as 2 points for the two conditional output states, 1 point for the average state, 3 points for the Holevo calculation, and 2 points for explaining the operational meaning of the Holevo quantity.

3d High partial scores are awarded for recognizing that when there are zero or one bit flips, the recovered logical channel acts as the identity, and that two or three bit flips produce a logical bit flip. 1 point is deducted for forgetting the final division by 3.