This exam is worth 100 points and has 5 problems.

Show all work and simplify your answers! Answers with no justification will receive no points unless otherwise noted.

Begin each problem on a new page.

DO NOT LEAVE THE EXAM UNTIL YOUR HAVE SATISFACTORILY SCANNED AND UPLOADED YOUR EXAM TO GRADESCOPE.

You are taking this exam in a proctored and honor code enforced environment. No calculators, cell phones, or other electronic devices or the internet are permitted during the exam. You are allowed one 8.5″ 11″ crib sheet with writing on one side.

0. At the top of the first page that you will be scanning and uploading to Gradescope, write the following statement and sign your name to it: "I will abide by the CU Boulder Honor Code on this exam." **FAILURE TO INCLUDE THIS STATEMENT AND YOUR SIGNATURE MAY RESULT IN A PENALTY.**

1. [2350/021424 (10 pts)] Write the word **TRUE**

4. [2350/021424 (20 pts)] Consider the two points $P(1;0;2)$ and $Q(\,1;2;0)$ and the plane M described by $2x\ \ 4y + z = 10$.

(a) (10 pts) Find the equation of the plane containing the points P and Q and perpendicular to the plane M. Write your answer in the standard form $ax + by + cz = d$.

(b) (10 pts) Find the symmetric equations of the line orthogonal to M and passing through point Q.

5. [2350/021424 (16 pts)] A particle is moving along the path $\mathbf{r}(t) = e^t\,\mathbf{i} + 2\,\mathbf{j} + e^{\ t}\,\mathbf{k}$.

(a) (4 pts) Without doing any computations, briefly explain why the unit binormal, $\mathbf{B}$, is always parallel to the y-axis.

(b) (12 pts) Recalling that the particle's velocity is a vector and its change, the acceleration, can be decomposed into two orthogonal components, answer the following questions.

  i. (5 pts) Find the rate of change of the direction of the particle as a function of t.

  ii. (7 pts) What is the speed of the particle at the point where its speed is not changing?