Your name: ______________________ Your NetID: ______________

- No notes, books, or electronics out. No hats or sunglasses on during the exam.
- When space is provided, show work that justifies your answer. In those problems, no credit will be given for correct answers without proper justification.
- Scratch paper is provided at the end of the exam. It will not be graded.
- No need to simplify your answers.
- Continuing to write after time has ended will result in the loss of all points on the pages written on.
- Mark your Discussion Section in the table below:

Discussion Section	Instructor	Time (TuTh)	Discussion Section	Instructor	Time (TuTh)
☐ ADA	Ferguson	8am	☐ BDA	Huo	8am
☐ ADB	Ferguson	9am	☐ BDB	Merriman	9am
☐ ADC	Zhang	10am	☐ BDC	Butler	10am
☐ ADD	Tian	11am	☐ BDD	Collier	11am
☐ ADE	Ackermann	12pm	☐ BDE	Ford	12pm
☐ ADF	Aramyan	1pm	☐ BDF	Menon	1pm
☐ ADG	Aramyan	2pm	☐ BDG	Menon	2pm
☐ ADH	Shakan	3pm	☐ BDH	Shi	3pm
☐ ADI	Shakan	4pm	☐ BDI	Shi	4pm
☐ ADJ	Li	8am	☐ BDJ	Chen	9am
☐ ADK	Li	9am	☐ BDK	Collier	10am
☐ ADL	Klajbor Goderich	10 am	☐ BDL	Butler	12 pm
☐ ADM	Klajbor Goderich	2pm	☐ BDM	Ford	2 pm
☐ ADN	Zhang	3pm	☐ BDN	Song	3 pm
☐ AD1	Quan	11am	☐ BDO	Song	4 pm
☐ AD2	Loeb	1 pm	☐ BDP	Chen	8 am
			☐ BDQ	Karve	4 pm
			☐ BDR	Karve	12 pm
			☐ BDS	Huo	10 am

Question:	1	2	3	4	5	6	7	8	9	10	11	12	Total
Points:	1	4	2	5	4	4	5	3	5	4	3	2	42
Score:													

1. (1 point) Mark your correct discussion section on the front page.

2. (4 points) Consider the vectors $\mathbf{u} = (1, 1, 1), \mathbf{v} = (2, -1, 2)$ in $\mathbb{R}^3$. Compute:

(a.) (1 point) $-\mathbf{u} + \mathbf{2v} =$

(b.) (2 points) $\text{proj}_{\mathbf{u}}\mathbf{v} =$

(c.) (1 point) $\mathbf{u} \cdot \mathbf{v} =$

3. (2 points) For two vectors $\mathbf{u}$ and $\mathbf{v}$ in $\mathbb{R}^3$, which of the following does $|\mathbf{u} \times \mathbf{v}|$ measure? Circle your answer.

(a.) The length of $\mathbf{u} - \mathbf{v}$.

(b.) The area of the parallelogram determined by $\mathbf{u}$ and $\mathbf{v}$.

(c.) The volume of the parallelepiped determined by $\mathbf{u}$, $\mathbf{v}$ and $\mathbf{u} \times \mathbf{v}$.

4. (5 points) Let A be the plane given by $x - y + 2z = 1$ and B the plane given by $x + y + z = 2$.

(a.) Find a normal vector $\mathbf{n}$ for the plane A. (1 point)

(b.) Find an equation of the plane C which contains the origin and is perpendicular to both A and B. **Show your work!** (4 points)

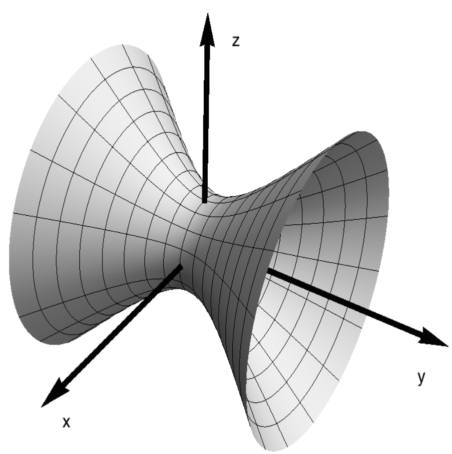
5. (4 points) Find the volume of the parallelepiped determined by the vectors $\mathbf{u} = (1, 1, 0)$, $\mathbf{v} = (0, 1, 1)$, and $\mathbf{w} = (1, 1, 1)$. **Show your work!**

6. (4 points) Let L be the line given by the parametric equations $x = 1 + 2t$ $y = -t$, and $z = 2 + t$. Let Q be the intersection point of the line L with the plane $3x - 2y + z = 14$. Find the coordinates of Q. **Show your work!**

7. (5 points) Find the distance between the two parallel planes $10x + 2y - 2z = 5$ and $5x + y - z = 1$. **Show your work!**

8. (3 points) Circle the equation for the quadric surface shown at right.

   1. $x^2 + y^2 - z^2 = -1$
   2. $x^2 - y^2 + z^2 = 1$
   3. $x - y^2 + z = 1$
   4. $x^2 - y^2 - z^2 = 1$
   5. $-x^2 + y^2 + z^2 = 1$



9. (5 points) Consider the function $f(x,y) = \frac{2xy - x^2y}{x^2+y^2}$ for $(x,y) \neq (0,0)$. Evaluate $\lim_{(x,y)\to(0,0)} f(x,y)$, or explain why it does not exist.

10. (4 points) Consider the function $f(x,y) = \ln(2x+y) + \sin(xy)$. **Show your work!** (2 points each)

    (a.) Compute $f_x(0,1)$.

    (b.) Compute $f_{xy}(\frac{\pi}{2}, 1)$.

11. (3 points) Let $f(x,y) = \frac{x^2 y}{x^2+y^2}$ for $(x,y) \neq (0,0)$ and at $f(0,0) = 1$. Circle the true statement.

(a.) f is continuous at $(0,0)$.

(b.) $\lim\limits_{(x,y)\to(0,0)} f(x,y)$ does not exist so f is discontinuous at $(0,0)$.

(c.) $\lim\limits_{(x,y)\to(0,0)} f(x,y)$ exists, but it is not equal to $f(0,0)$, so f is discontinuous at $(0,0)$.

12. (2 points) **Extra Credit Problem** Let $f(x,y) = \frac{2x^2 y}{x^2+y^2}$.

(a.) Find a $\delta > 0$ such that, if $0 < \sqrt{x^2+y^2} < \delta$, then $|f(x,y)| < \frac{1}{5}$. Justify your answer. (1 point)

(b.) Find an expression for $\delta > 0$ in terms of ϵ so that for *every* $\epsilon > 0$, whenever $0 < \sqrt{x^2+y^2} < \delta$, then $|f(x,y)| < \epsilon$. Justify your answer. (1 point)

Scratch work will not be graded.

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