Snow College Mathematics Contest

March 24, 2026 **Senior Division: Grades 10-12** **Form: T**

Please read all instructions on this page very carefully.

1. Leave this booklet closed until you are instructed to begin.
2. Blacken the box for your test version (Form T) on the upper left side of the answer sheet. Make sure your answer sheet has your name already printed (if not, return to the registration table).
3. This is a two-hour examination consisting of 40 multiple choice problems. Completely blacken the box on the answer sheet for the single best answer to each question you choose to answer. Completely erase any answers you wish to change. Do not make stray marks outside the boxes.
4. Avoid random guessing as there is a penalty for wrong answers. There is no penalty for leaving a question blank. The formula for scoring the test is $\text{Score} = 40 + 4R - W$ where R and W denote the number right and wrong respectively. The possible scores range from 0 to 200.
5. Ties will be broken by the first discrepancy in the following five problems *in order*: 2, 10, 17, 19, 39. In the event of no discrepancies in those problems, the tie will be broken by a coin toss.
6. No calculators are allowed. Diagrams are not necessarily drawn to scale.
7. Do not talk or disrupt other test takers during the exam. Cell phones must be OFF (not just on silent or vibrate, but OFF). No earbuds are allowed.
8. Please raise your hand if you need scratch paper or a new pencil; a proctor will assist you.
9. The proctors have been advised to **not** answer questions pertaining to the exam.
10. If you have time we recommend you recheck your answers. If you finish early you may quietly turn your answer sheet in and leave. After the two hour time limit is up the proctors will call for all answer sheets; hand them in promptly.

After the test:

1. You may keep this test booklet and the pencils.
2. For those who RSVP'd to take a department tour, consult information and signage for tours to start at 12:10. For those not touring a department, lunch may be purchased at the Snow College Cafeteria or downtown. In any event, you should plan to be back at the LDS Institute by 1:20 p.m. for the scores and presentation of the awards.
3. Top individual and team scorers in each classification will receive prizes.
4. Thanks for coming; we hope you had fun and learned some math. Your instructors will be happy to work the problems for you. They will also be given your answer sheets.

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Bubble in clearly the single best choice for each question you choose to answer.

1. Suppose $\boldsymbol{u} = u_1\hat{\boldsymbol{\imath}} + u_2\hat{\boldsymbol{\jmath}}$ and $\boldsymbol{v} = v_1\hat{\boldsymbol{\imath}} + v_2\hat{\boldsymbol{\jmath}}$ are non-zero vectors and their dot product is $\boldsymbol{u} \cdot \boldsymbol{v} = 0$. Which must be true?

   (A) $\dfrac{u_2}{u_1} \cdot \dfrac{v_2}{v_1} = -1$

   (B) $\dfrac{u_2}{u_1} \cdot \dfrac{v_2}{v_1} = 0$

   (C) $u_1 v_2 = 0$ and $u_2 v_1 = 0$

   (D) $u_1 v_2 = -v_1 u_2$

   (E) $\|\boldsymbol{u}\|\|\boldsymbol{v}\| \leq 0$ where $\|\boldsymbol{u}\|$ is the magnitude of $\boldsymbol{u}$.

2. Points A, B, and C are collinear and each is the center of a circle of radius 1. The outer circles pass through point B and the middle circle passes through points A and C. What is the total shaded area?

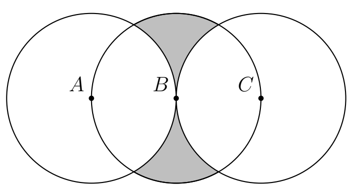
   (A) 3

   (B) $\sqrt{3}$

   (C) $\frac{\pi}{3}$

   (D) π

   (E) $(\sqrt{3} - \pi/3)$



3. Find the area between the function $y = \frac{1}{x^2+1}$ and the x-axis from 0 to ∞.

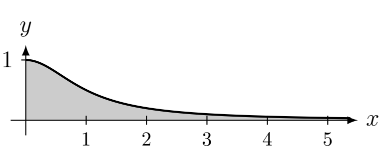
   (A) 1

   (B) $\pi/2$

   (C) ∞

   (D) $\sqrt{2}$

   (E) $\pi\sqrt{2}/2$



4. One extension of the real numbers is the complex numbers $a + b\mathrm{i}$, where a, b are real numbers and $\mathrm{i}^2 = -1$. Another is the dual numbers $a + b\varepsilon$, where a, b are real numbers and $\varepsilon^2 = 0$. Which statement about $f(a+b\varepsilon)$ is true? (Hints: Check a simple case such as $f(x) = x^2$. f' means derivative.)

   (A) $f(a + b\varepsilon) = f(a) + bf'(a)\varepsilon$

   (B) $f(a + b\varepsilon) = f(b) + af'(a)\varepsilon$

   (C) $f(a + b\varepsilon) = bf'(a)\varepsilon$

   (D) $f(a + b\varepsilon) = af'(b)\varepsilon$

   (E) $f(a + b\varepsilon) = af'(b)\varepsilon + bf'(a)\varepsilon$

5. A square is inscribed in a unit circle centered at the origin. Inscribed in the square is a second circle also centered at the origin. Find the sum of the gray areas if this process is repeated indefinitely.

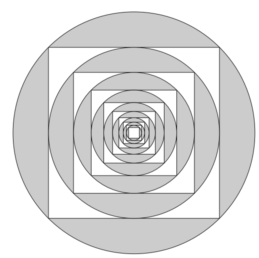
   (A) $2(\pi - 2)$

   (B) $\pi - \sqrt{2}$

   (C) $\pi - 2$

   (D) $2(\pi - \sqrt{2})$

   (E) $\pi/2 + 2\sqrt{2}/3$



6. How many different 5-card hands can be drawn from a standard 52-card deck?

   (A) $\dfrac{47!}{5!\,52!}$

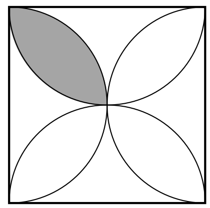
   (B) $\dfrac{47!}{5!}$

   (C) $\dfrac{52!}{47!}$

   (D) $\dfrac{52!}{5!\,47!}$

   (E) $\dfrac{52!}{5!}$

7. What is the area of the shaded region if the inside curves are semicircles inscribed in a square of side length 2?



(A) $2 - \frac{\pi}{2}$

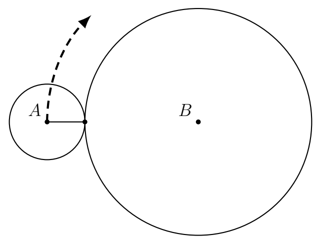
(B) $1 - \frac{\pi}{4}$

(C) $\pi - \frac{1}{2}$

(D) $\frac{\pi}{2} - \frac{1}{2}$

(E) $\frac{\pi}{2} - 1$

8. The radius of circle A is $\frac{1}{3}$ the radius of circle B. Starting from the position shown, circle A rolls without slipping around circle B. When circle A returns to its original position how many rotations will it have made?



(A) 4

(B) $4\frac{1}{3}$

(C) $4\frac{2}{3}$

(D) 5

(E) 6

9. Each Fibonacci number F_n is the sum of the two previous ones: $F_n = F_{n-1} + F_{n-2}$, with $F_1 = 1$, $F_2 = 1$. Then, $F_3 = 2$, $F_4 = 3$, $F_5 = 5, \ldots$. Use the remarkable fact that

$$\gcd(F_m, F_n) = F_{\gcd(m,n)}$$

(where gcd is the greatest common divisor) to find the gcd of 144 and 610.

(A) 2

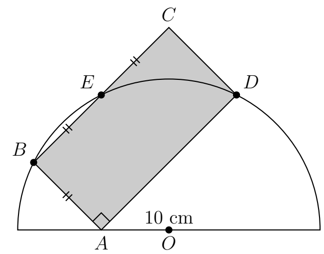
(B) 4

(C) 6

(D) 8

(E) 12

10. Rectangle $ABCD$ intersects a circle with diameter of 10 cm at the points B, E, and D. Segments AB, BE, and EC are congruent. What is the area of the rectangle?



(A) $10\,\text{cm}^2$

(B) $20\,\text{cm}^2$

(C) $22\,\text{cm}^2$

(D) $2\sqrt{10}\,\text{cm}^2$

(E) $4\sqrt{10}\,\text{cm}^2$

11. Solve the following equation for x.

$$\sqrt{\frac{x}{\sqrt{\frac{x}{\sqrt{\frac{x}{\sqrt{x}}}}}}} = 32$$

(A) 2^4

(B) 2^8

(C) 2^{10}

(D) 2^{12}

(E) 2^{16}

12. Solve the equation. $|x| = -x$

(A) $x = 0$

(B) $(-\infty, 0]$

(C) $(-\infty, 0)$

(D) $(0, \infty)$

(E) $[0, \infty)$

13. Solve the equation for x.

$$\frac{9^{x-5}}{4^{x-8}} = 144$$

(A) $\log_4 9$

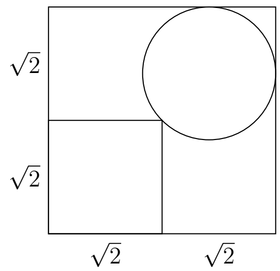
(B) $144 \log_9 4$

(C) 6

(D) 8

(E) 9

14. Find the diameter of the circle in the diagram.



(A) $2/(1+\sqrt{2})$

(B) $4/(1+\sqrt{2})$

(C) $2\sqrt{2}$

(D) $2\sqrt{2}/(1+\sqrt{2})$

(E) $3/2$

15. On its natural domain, where is a local maximum of the function $f(x) = x^3 - 3x^2$?

(A) -2

(B) 0

(C) 1

(D) 2

(E) 4

16. If $f(x_1) + f(x_2) = f(x_1 + x_2)$ for all real numbers x_1 and x_2, which of the following could define f?

(A) $f(x) = x + 1$

(B) $f(x) = 2x$

(C) $f(x) = \frac{1}{x}$

(D) $f(x) = e^x$

(E) $f(x) = x^2$

17. The supremum of a set A of real numbers, notated as $\sup A$, is the smallest real number $\geq$ to all the numbers in A. For instance, $\sup([1,2)) = 2$. Analogously, we can define the infimum $\inf([1,2)) = 1$ for getting the greatest number $\leq$ all the numbers in A. Let

$$A_N = \left\{(-1)^n \cdot \left(1 + \left(\frac{1}{2}\right)^n\right)\right\}_{n=N}^{\infty}$$

This means that A_N is all elements of the sequence starting at N. Then, calculate:

$$\lim_{N\to\infty} \sup A_N - \lim_{N\to\infty} \inf A_N$$

(A) -1

(B) 0

(C) 1

(D) 2

(E) 3

18. Imagine a 3-D unit cube tucked in the corner of the first octant; the vertices are ordered triples $(0,0,0)$, $(0,0,1)$, $\ldots(1,1,1)$. An edge is defined between any two vertices that differ in only one dimension. How many edges are there?

(A) 8

(B) 12

(C) 16

(D) 24

(E) 27

19. Imagine a 4-D unit hypercube tucked in the corner of the first hyperoctant; the vertices are ordered quadruples $(0,0,0,0)$, $(0,0,0,1)$, $\ldots(1,1,1,1)$. An edge is defined between any two vertices that differ in only one dimension. How many edges are there?

(A) 16

(B) 20

(C) 24

(D) 28

(E) 32

20. What is the output of the following Python program?

```
a = 1
b = 2
while a < 20:
    print(a)
    a = b
    b = a + b
```

(A) the powers of 2 less than 20

(B) the squares of numbers less than 20

(C) the triangular numbers less than 20

(D) the counting numbers less than 20

(E) the prime numbers less than 20

21. The Pauli spin matrices σ_1, σ_2, and σ_3 appear in quantum mechanics. They are

$$\sigma_1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \quad \sigma_2 = \begin{bmatrix} 0 & -\mathrm{i} \\ \mathrm{i} & 0 \end{bmatrix} \quad \sigma_3 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

where $\mathrm{i}^2 = -1$. What is $(\sigma_2)^2$?

(A) σ_1

(B) σ_2

(C) σ_3

(D) $-\sigma_2$

(E) I

22. In a pair of fair six-sided dice, one has the regular number of pips on each face but the other is blank on all faces. Which numbers of pips can you put on the faces of the second die so the sample space of the sum of rolling both dice is $\{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$ and every outcome has equal probability?

(A) 0, 2, 4, 6, 8, 10

(B) 1, 2, 3, 4, 5, 6

(C) 1, 2, 2, 3, 3, 4

(D) 2, 2, 4, 4, 6, 6

(E) 0, 0, 0, 6, 6, 6

23. In modular arithmetic, $a \equiv b \mod c$ if a/c has a remainder b. You can add, subtract, and multiply, but not divide in modular arithmetic. However, you can use the multiplicative inverse (provided it exists). What is the multiplicative inverse of $16 \mod 19$? In other words, find x such that $x \times 16 \equiv 1 \mod 19$.

(A) 4

(B) 6

(C) 9

(D) 13

(E) 15

24. The price of a stock rose 20% on Monday, fell 10% on Tuesday, and increased by 1/6 on Wednesday. By what percent did the price rise from before the market opened on Monday to after the market closed on Wednesday?

(A) 24

(B) 26

(C) 28

(D) 30

(E) 32

25. The function $y = f(x)$ has zeros -2 and 6. Find the zeros of $y = -3f(2 - 2x)$.

(A) $\{2, -2\}$

(B) $\{5, 1\}$

(C) $\{4, -1\}$

(D) $\{-1, -5\}$

(E) $\{1, -3\}$

26. For $b > c > 0$, both x^2+bx+8 and x^2+cx+8 factor over the integers. Find $b - c$.

(A) 1

(B) 2

(C) 3

(D) 4

(E) 5

27. Which of the following is a solution to the system of nonlinear equations.

$$xy = -8$$
$$yz = -9$$
$$xz = 10$$

(A) $\left(-\frac{4\sqrt{5}}{3}, -\frac{6\sqrt{5}}{5}, -\frac{3\sqrt{5}}{2}\right)$

(B) $\left(\frac{4\sqrt{5}}{3}, -\frac{6\sqrt{5}}{5}, -\frac{3\sqrt{5}}{2}\right)$

(C) $\left(-\frac{4\sqrt{5}}{3}, -\frac{6\sqrt{5}}{5}, \frac{3\sqrt{5}}{2}\right)$

(D) $\left(-\frac{4\sqrt{5}}{3}, \frac{6\sqrt{5}}{5}, -\frac{3\sqrt{5}}{2}\right)$

(E) $\left(\frac{4\sqrt{5}}{3}, \frac{6\sqrt{5}}{5}, \frac{3\sqrt{5}}{2}\right)$

28. The **s**ound **i**ntensity **l**evel (in decibels) is given by $\text{SIL} = (10\,\text{dB})\log_{10}\left(\frac{I}{I_0}\right)$, where I is the sound intensity and I_0 is a reference intensity (both in W/m^2). If a sound is 1000 times more intense than the reference level, how many decibels louder is it?

(A) 10 dB

(B) 20 dB

(C) 30 dB

(D) 40 dB

(E) 60 dB

29. Given the following equations and inequalities, where each letter (A, B, C, D, or F) represents a real number, which letter has the largest value?

$$D + C = B + F$$
$$D + A > C + F$$
$$A < B < D$$

(A) A

(B) B

(C) C

(D) D

(E) F

30. What is the probability that the product of the numbers rolled on three fair six-sided dice is prime?

(A) 1/36

(B) 1/24

(C) 1/16

(D) 1/12

(E) 1/8

31. A bridge charges 2-axled vehicles a \$5 toll and 3-axled vehicles an \$8 toll. In an hour the bridge collected \$741 from 120 vehicles. How much would the bridge have collected if tolls were \$1 higher for 2-axled and \$2 higher for 3-axled vehicles?

(A) \$888

(B) \$908

(C) \$926

(D) \$934

(E) \$1012

32. In the 5×5 grid shown, each cell contains one of the digits 1 to 5 so that each row and each column has exactly one of each digit. Find the entry in row 3, column 4.

(A) 1

(B) 2

(C) 3

(D) 4

(E) 5

1	2			
2				
				5
			5	4

33. What is the remainder when 10 000 000 000 000 003 is divided by 9?

(A) 0

(B) 1

(C) 4

(D) 7

(E) 8

34. What is the last digit of 3^{2026}?

(A) 3

(B) 1

(C) 7

(D) 9

(E) 5

35. A square has a side length of 10. The midpoints of each side are connected to form a diamond (rotated square). What is the area of the diamond?

(A) 25

(B) 30

(C) 40

(D) 45

(E) 50

36. Let $\phi(n)$ be the number of integers 1 through n that only share a common factor of 1 with n. For example, $\phi(4) = 2$ counts the numbers 1 and 3 which do not share a common factor with 4. Find

$$\phi(122) + \phi(61) + \phi(2) + \phi(1)$$

(A) 120

(B) 121

(C) 122

(D) 123

(E) 124

37. Evaluate the sum:

$$\sum_{n=1}^{\infty} \left(\frac{1}{n} - \frac{1}{n+1} \right)$$

(A) $\frac{1}{4}$

(B) $\frac{1}{2}$

(C) 1

(D) 2

(E) 4

38. In $\triangle ABC$, the three sides have lengths 4, 5, and 6. The sum of the cosines (not the cosine of the sums) of the largest and smallest angles of $\triangle ABC$ is a rational number m/n in lowest terms. Find $m + n$.

(A) 15

(B) 17

(C) 24

(D) 37

(E) 45

39. Let p and q be prime numbers such that $p^2 - 2q^2 = 1$. How many such pairs (p, q) exist?

(A) 0

(B) 1

(C) 2

(D) 11

(E) infinitely many

40. How many different ways can you orient a cube to fit into a cubic slot fitted for it?

(A) 12

(B) 16

(C) 20

(D) 24

(E) 28