

2026 UIL CALCULATOR APPLICATIONS INVITATIONAL EXAM A – OFFICIAL SCORING KEY

CANONICAL ANSWERS (3 SIGNIFICANT DIGITS) • SCIENTIFIC NOTATION • GRADING TOLERANCES [PAGE 1 OF 6]

#	OFFICIAL CONTEST ANSWER (3 SIG FIGS)	SCIENTIFIC NOTATION	ACCEPTANCE INTERVAL (±2 UNITS)
1	135	1.35×10^2	[133, 137]
2	109	1.09×10^2	[107, 111]
3	18.3	1.83×10^1	[18.1, 18.5]
4	5.90	5.90×10^0	[5.88, 5.92]
5	0.0670	6.70×10^{-2}	[0.0668, 0.0672]
6	59.4	5.94×10^1	[59.2, 59.6]
7	20.9	2.09×10^1	[20.7, 21.1]
8	393	3.93×10^2	[391, 395]
9	\$77.75	7.78×10^1	[77.6, 78.0]
10	1.16×10^3 m	1.16×10^3	[1.14, 1.18] $\times 10^3$
11	1.53	1.53×10^0	[1.51, 1.55]
12	12.6	1.26×10^1	[12.4, 12.8]
13	0.319	3.19×10^{-1}	[0.317, 0.321]
14	119	1.19×10^2	[117, 121]
15	1.99	1.99×10^0	[1.97, 2.01]
16	6.21	6.21×10^0	[6.19, 6.23]
17	10.7	1.07×10^1	[10.5, 10.9]
18	0.00439	4.39×10^{-3}	[0.00437, 0.00441]
19	2.23 hrs	2.23×10^0	[2.21, 2.25]
20	445 m ²	4.45×10^2	[443, 447]
21	20.7	2.07×10^1	[20.5, 20.9]
22	16.7	1.67×10^1	[16.5, 16.9]
23	0.0435	4.35×10^{-2}	[0.0433, 0.0437]
24	54.2	5.42×10^1	[54.0, 54.4]
25	3.84	3.84×10^0	[3.82, 3.86]
26	18.7	1.87×10^1	[18.5, 18.9]
27	5.76	5.76×10^0	[5.74, 5.78]
28	15.7	1.57×10^1	[15.5, 15.9]
29	101 min	1.01×10^2	[98.6, 103]
30	74.6 deg	7.46×10^1	[74.4, 74.8]
31	1.57	1.57×10^0	[1.55, 1.59]
32	0.463	4.63×10^{-1}	[0.461, 0.465]
33	6.12	6.12×10^0	[6.10, 6.14]
34	0.989	9.89×10^{-1}	[0.987, 0.991]
35	5.33	5.33×10^0	[5.31, 5.35]

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CANONICAL ANSWERS (3 SIGNIFICANT DIGITS) • SCIENTIFIC NOTATION • GRADING TOLERANCES [PAGE 2 OF 6]

#	OFFICIAL CONTEST ANSWER (3 SIG FIGS)	SCIENTIFIC NOTATION	ACCEPTANCE INTERVAL (±2 UNITS)
36	0.104	1.04×10^{-1}	[0.102, 0.106]
37	1.41	1.41×10^0	[1.39, 1.43]
38	0.996	9.96×10^{-1}	[0.994, 0.998]
39	13.0 g	1.30×10^1	[12.8, 13.2]
40	76.3 m	7.63×10^1	[76.1, 76.5]
41	1.76	1.76×10^0	[1.74, 1.78]
42	61.5	6.15×10^1	[61.3, 61.7]
43	2.19	2.19×10^0	[2.17, 2.21]
44	0.955	9.55×10^{-1}	[0.953, 0.957]
45	0.695	6.95×10^{-1}	[0.693, 0.697]
46	5.65	5.65×10^0	[5.63, 5.67]
47	1.58	1.58×10^0	[1.56, 1.60]
48	71.0	7.10×10^1	[70.8, 71.2]
49	38.6 cm	3.86×10^1	[38.4, 38.8]
50	202 m ²	2.02×10^2	[200, 204]
51	50388 [INT]	5.04×10^4	[50388]
52	240240 [INT]	2.40×10^5	[240240]
53	14.4	1.44×10^1	[14.2, 14.6]
54	24.3	2.43×10^1	[24.1, 24.5]
55	1.53	1.53×10^0	[1.51, 1.55]
56	1.48	1.48×10^0	[1.46, 1.50]
57	7.00	7.00×10^0	[6.98, 7.02]
58	3.34	3.34×10^0	[3.32, 3.36]
59	1.91×10^3 cm ³	1.91×10^3	[1.89, 1.93] $\times 10^3$
60	7.32×10^3 cm ³	7.32×10^3	[7.30, 7.34] $\times 10^3$
61	12.2	1.22×10^1	[12.0, 12.4]
62	0.245	2.45×10^{-1}	[0.243, 0.247]
63	0.672	6.72×10^{-1}	[0.670, 0.674]
64	1.27	1.27×10^0	[1.25, 1.29]
65	3.07	3.07×10^0	[3.05, 3.09]
66	4.32	4.32×10^0	[4.30, 4.34]
67	4.91	4.91×10^0	[4.89, 4.93]
68	9.70	9.70×10^0	[9.68, 9.72]
69	657 in ³	6.57×10^2	[655, 659]
70	747 m	7.47×10^2	[745, 749]

STACKCALC32 RPM BENCHMARK: 580 KEYSTROKES vs. 1176 ALGEBRAIC (SAVING 596 KEYS, 50.7% FASTER)

GRADER 1 INITIALS: _____ GRADER 2 INITIALS: _____ CONTEST DIRECTOR: _____

SCORING RULE: +5 points for each correct answer; -4 points for each error or skipped question up to last attempted.

PART II: DETAILED WORD PROBLEM & GEOMETRY WORKED SOLUTIONS

Formal Mathematical Modeling, Formula Setups & StackCalc RPN Keystroke Workflows

PROBLEM 9 • TEST BENCH TOOL DISCOUNT & SALES TAX**ANSWER: \$77.75**

A digital logic probe kit priced at \$84.50 is discounted by 15%. With an 8.25% sales tax applied to the discounted price, what is the final purchase cost?

GOVERNING MODEL: Final Cost = Original Price $\times$ (1 - Discount Rate) $\times$ (1 + Tax Rate)

NUMERICAL SETUP: Final Cost = $P_0 \times (1 - d) \times (1 + t)$

STEP-BY-STEP MATHEMATICAL REASONING:

Calculate net purchase price after lab equipment discount: $P_{\text{net}} = P_0 \cdot (1 - d)$. Then apply sales tax: $P_{\text{final}} = P_{\text{net}} \cdot (1 + t)$. In competition scoring, currency answers [\$] are rounded to the nearest cent.

CALCULATOR FLOW: [84.50] [ENTER] [0.85] [$\times$] [1.0825] [$\times$] -> \$77.75

PROBLEM 10 • 3D PRINTING FILAMENT & LINEAR DENSITY**ANSWER: 1.16×10^3 m**

Conductive copper-infused 3D printing filament weighs 3.65 grams per meter. How many meters of filament are wound onto a 4.25 kilogram spool?

GOVERNING MODEL: Length = Total Mass / Linear Density [with kg $\rightarrow$ g conversion]

NUMERICAL SETUP: Length (m) = [Mass (kg) $\times$ 1000 g/kg] / Linear Density (g/m)

STEP-BY-STEP MATHEMATICAL REASONING:

Convert spool shipping mass from kg to grams (multiply by 1,000). Divide total grams by filament linear density in grams per meter to obtain total printable filament length in meters.

CALCULATOR FLOW: [4.25] [ENTER] [1000] [$\times$] [3.65] [$\div$] -> 1.16×10^3 m

PROBLEM 19 • PARALLEL PROCESSING & VACUUM CHAMBER EVACUATION**ANSWER: 2.23 hrs**

In an automated resin 3D printing station, vacuum degassing pump A evacuates the resin chamber in 3.80 hours, while auxiliary pump B requires 5.40 hours. How many hours will it take to degas the chamber if both pumps run simultaneously?

GOVERNING MODEL: $1/t_{\text{total}} = 1/t_A + 1/t_B \Rightarrow t_{\text{total}} = 1 / (1/t_A + 1/t_B)$

NUMERICAL SETUP: $t_{\text{total}} = 1 / [(1 / t_A) + (1 / t_B)]$

STEP-BY-STEP MATHEMATICAL REASONING:

Each degassing pump, printer, or resin dispenser operates at rate $1/t$. Running concurrently, their combined rate is $R = 1/t_A + 1/t_B$. Time to complete is reciprocal $1 / R$. In RPN: enter t_A , press $[1/x]$, enter t_B , press $[1/x]$, add $[+]$, and invert with $[1/x]$.

CALCULATOR FLOW: [3.8] $[1/x]$ [5.4] $[1/x]$ $[+]$ $[1/x]$ -> 2.23 hrs

PROBLEM 20 • TURNTABLE FLANGE & COMMUTATOR RING AREA**ANSWER: 445 m²**

A 3D printed circular planetary gear has an inner sun gear radius of 18.5 meters surrounded by an outer ring gear radius of 22.0 meters. Find the surface area of the gear annulus in square meters.

GOVERNING MODEL: Area = $\pi \times (R_{\text{outer}}^2 - r_{\text{inner}}^2)$

NUMERICAL SETUP: Area = $\pi \times [(R_{\text{outer}})^2 - (r_{\text{inner}})^2]$

STEP-BY-STEP MATHEMATICAL REASONING:

The area of an annular region between concentric circles equals outer circle area minus inner cutout area: $\pi \cdot (R^2 - r^2)$. Compute both radii squared on the stack, subtract, and multiply by π .

CALCULATOR FLOW: [22] [$\times^2$] [18.5] [$\times^2$] $[-]$ [π] [$\times$] -> 445 m²

PROBLEM 29 • LASER GANTRY TRIANGULATION & VERTICAL MAST HEIGHT**ANSWER: 101 min**

Two autonomous mobile educational delivery rovers situated 52.0 miles apart travel directly toward each other with constant speeds of 13.5 mph and 17.5 mph respectively. In how many minutes will they meet?

GOVERNING MODEL: $h = \text{Baseline Distance} / [\cot(\theta_1) - \cot(\theta_2)]$

NUMERICAL SETUP: $h = d / [(1 / \tan(\theta_1)) - (1 / \tan(\theta_2))]$

STEP-BY-STEP MATHEMATICAL REASONING:

From two calibration baseline positions separated by advance distance d, vertical height h satisfies $\cot(\theta_1) - \cot(\theta_2) = d / h$. Invert $\tan(\theta_1)$ and $\tan(\theta_2)$, subtract on the stack, take reciprocal $[1/x]$, and multiply by distance d.

CALCULATOR FLOW: [52] [ENTER] [13.5] [ENTER] [17.5] [+] [+] [60] [×] -> 101 min

PROBLEM 30 • SMD PLACEMENT MACHINE PRODUCTION RATE & PROPORTION**ANSWER: 74.6 deg**

An articulated robotic pick-and-place boom measuring 32.0 feet long leans against a vertical test fixture with its base resting 8.50 feet away from the fixture. What acute angle in degrees does the boom make with the horizontal ground?

GOVERNING MODEL: $\text{Placed Components} = (\text{Rate per Minute}) \times \text{Total Time}$

NUMERICAL SETUP: $\text{Count} = (N_1 / t_1) \times t_2$

STEP-BY-STEP MATHEMATICAL REASONING:

Compute component placement rate per minute (N_1 / t_1) , then multiply by total operating duration t_2 to determine parts placed.

CALCULATOR FLOW: [DEG] [8.5] [ENTER] [32] [+] [ACOS] -> 74.6 deg

PROBLEM 39 • SENSOR CALIBRATION & EXPONENTIAL RADIOACTIVE DECAY**ANSWER: 13.0 g**

A radioactive sensor calibration isotope used in an electronic scintillation detector has a half-life of 14.2 days. If an initial laboratory vial contains 85.0 grams of the active isotope, what mass in grams remains active after 38.5 days?

GOVERNING MODEL: $M(t) = M_0 \times (1/2)^{(t / t_{\text{half}})}$

NUMERICAL SETUP: $M(t) = M_0 \times (0.5)^{(\text{Elapsed_Time} / \text{Half_Life})}$

STEP-BY-STEP MATHEMATICAL REASONING:

Radioactive decay follows exponential halving. The number of elapsed half-life cycles is $n = t / t_{\text{half}}$. Raise 0.5 to power n and multiply by initial sensor activity M_0 .

CALCULATOR FLOW: [38.5] [ENTER] [14.2] [÷] [0.5] [x<>y] [y^x] [85] [×] -> 13.0 g

PROBLEM 40 • LASER GANTRY TRIANGULATION & VERTICAL MAST HEIGHT**ANSWER: 76.3 m**

An optical laser inspection sensor measures the vertical height of a 3D printer gantry tower. From calibration point A, the angle of elevation to the gantry apex is 34.2°. Moving 45.0 meters closer along the rail to point B, the elevation angle increases to 48.6°. Determine the height of the gantry tower in meters.

GOVERNING MODEL: $h = \text{Baseline Distance} / [\cot(\theta_1) - \cot(\theta_2)]$

NUMERICAL SETUP: $h = d / [(1 / \tan(\theta_1)) - (1 / \tan(\theta_2))]$

STEP-BY-STEP MATHEMATICAL REASONING:

From two calibration baseline positions separated by advance distance d, vertical height h satisfies $\cot(\theta_1) - \cot(\theta_2) = d / h$. Invert $\tan(\theta_1)$ and $\tan(\theta_2)$, subtract on the stack, take reciprocal $[1/x]$, and multiply by distance d.

CALCULATOR FLOW: [DEG] [34.2] [TAN] [1/x] [48.6] [TAN] [1/x] [-] [1/x] [45] [×] -> 76.3 m

PROBLEM 49 • RIGHT TRIANGLE TRIGONOMETRY

ANSWER: 38.6 cm

RIGHT TRIANGLE: In the right triangle shown below, hypotenuse $c = 64.5$ cm and acute angle $\theta = 36.8^\circ$. Calculate the length of opposite side a .

GOVERNING MODEL: $a = c \times \sin(\theta)$ or $b = c \times \cos(\theta)$

NUMERICAL SETUP: $a = 64.5 \times \sin(36.8^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

In a right triangle, the opposite leg equals hypotenuse c multiplied by $\sin(\theta)$. With $c = 64.5$ and acute angle $\theta = 36.8^\circ$, calculate in Degree mode and round non-integers to 3 significant figures.

CALCULATOR FLOW: [DEG] [64.5] [ENTER] [36.8] [SIN] [$\times$] -> 38.6 cm

PROBLEM 50 • CIRCULAR SECTOR AREA

ANSWER: 202 m²

CIRCULAR SECTOR: For the circular sector diagrammed below, radius $r = 18.4$ m and central angle $\theta = 68.5^\circ$. Determine the total area of the shaded sector in square meters.

GOVERNING MODEL: $\text{Area} = \pi \times r^2 \times (\theta / 360^\circ)$

NUMERICAL SETUP: $\text{Area} = \pi \times (18.4)^2 \times (68.5^\circ / 360^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

A circular sector represents a fraction $(\theta / 360^\circ)$ of a full circle. Square radius $r = 18.4$, multiply by angle $\theta = 68.5^\circ$, multiply by π , and divide by 360.

CALCULATOR FLOW: [18.4] [$\times$] [68.5] [$\times$] [π] [$\times$] [360] [$\div$] -> 202 m²

PROBLEM 59 • RIGHT CIRCULAR CONE VOLUME

ANSWER: 1.91×10^3 cm³

RIGHT CIRCULAR CONE: The solid cone shown has base radius $r = 9.20$ cm and vertical height $h = 21.5$ cm. Calculate the volume of the cone in cubic centimeters.

GOVERNING MODEL: $V = (1/3) \times \pi \times r^2 \times h$

NUMERICAL SETUP: $V = (1/3) \times \pi \times (9.2)^2 \times (21.5)$

STEP-BY-STEP MATHEMATICAL REASONING:

The cone volume equals one-third base area times vertical height. Square base radius $r = 9.2$, multiply by vertical height $h = 21.5$, multiply by π , and divide by 3.

CALCULATOR FLOW: [9.2] [$\times$] [21.5] [$\times$] [π] [$\times$] [3] [$\div$] -> 1.91×10^3 cm³

PROBLEM 60 • CONICAL FRUSTUM VOLUME

ANSWER: 7.32×10^3 cm³

CONICAL FRUSTUM: A truncated cone has lower base radius $R = 14.5$ cm, upper base radius $r = 7.80$ cm, and vertical height $h = 18.2$ cm. Calculate the frustum volume in cubic centimeters.

GOVERNING MODEL: $V = (1/3) \times \pi \times h \times (R^2 + R \cdot r + r^2)$

NUMERICAL SETUP: $V = (1/3) \times \pi \times 18.2 \times [(14.5)^2 + (14.5)(7.8) + (7.8)^2]$

STEP-BY-STEP MATHEMATICAL REASONING:

A truncated cone volume is $\pi/3 \cdot h \cdot (R^2 + R \cdot r + r^2)$. On StackCalc, accumulate $R^2 + R \cdot r + r^2$ on the stack, multiply by vertical height 18.2, multiply by π , and divide by 3.

CALCULATOR FLOW: [14.5] [$\times$] [14.5] [ENTER] [7.8] [$\times$] [+] [7.8] [$\times$] [+] [18.2] [$\times$] [π] [$\times$] [3] [$\div$] -> 7.32×10^3 cm³

PROBLEM 69 • CALCULUS OPTIMIZATION: MODULAR ELECTRONICS ENCLOSURE**ANSWER: 657 in³**

A 3D printed modular electronics enclosure with an open top and square base is sliced using 360 square inches of polymer wall area. Using calculus optimization, determine the maximum theoretical internal volume in cubic inches.

GOVERNING MODEL: $V(x) = x \cdot (S - x^2) / 4$; Critical Point: $x = \sqrt{S / 3}$

NUMERICAL SETUP: Max Volume = $\sqrt{S / 3} \times [S - (S / 3)] / 4$

STEP-BY-STEP MATHEMATICAL REASONING:

For a 3D printed modular electronics enclosure with open top and square base of surface area $S = x^2 + 4xh$, height is $h = (S - x^2)/(4x)$.

Maximizing volume $V(x)$ via $dV/dx = 0$ yields $x = \sqrt{S/3}$. Evaluate maximum internal capacity in cubic units.

CALCULATOR FLOW: [120] [√x] [60] [×] -> 657 in³

PROBLEM 70 • TACTILE KEY SWITCH EJECTION DYNAMICS & KINEMATICS**ANSWER: 747 m**

In an automated tactile switch testing rig, a spring-loaded key switch plunger is ejected with launch velocity $v_0 = 86.4$ m/s at an elevation angle of 39.5° above horizontal across a level test track. Taking gravitational acceleration $g = 9.81$ m/s², determine the horizontal trajectory distance in meters.

GOVERNING MODEL: Range = $(v_0^2 \times \sin(2\theta)) / g$ [$g = 9.81$ m/s²]

NUMERICAL SETUP: Range = $[(v_0)^2 \times \sin(2 \times \theta)] / 9.81$

STEP-BY-STEP MATHEMATICAL REASONING:

In switch drop-and-ejection reliability testing over a level test bench, horizontal flight range is $R = v_0^2 \cdot \sin(2\theta) / g$. Square launch velocity v_0 , multiply by $\sin(2\theta)$ in DEG mode, and divide by gravitational constant 9.81 m/s².

CALCULATOR FLOW: [DEG] [86.4] [x²] [39.5] [ENTER] [2] [×] [SIN] [×] [9.81] [÷] -> 747 m