

2026 UIL CALCULATOR APPLICATIONS INVITATIONAL EXAM B – 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	159	1.59×10^2	[157, 161]
2	140	1.40×10^2	[138, 142]
3	18.7	1.87×10^1	[18.5, 18.9]
4	5.73	5.73×10^0	[5.71, 5.75]
5	0.0531	5.31×10^{-2}	[0.0529, 0.0533]
6	70.9	7.09×10^1	[70.7, 71.1]
7	17.3	1.73×10^1	[17.1, 17.5]
8	443	4.43×10^2	[441, 445]
9	\$96.99	9.70×10^1	[96.8, 97.2]
10	1.41×10^3 m	1.41×10^3	$[1.39, 1.43] \times 10^3$
11	1.35	1.35×10^0	[1.33, 1.37]
12	14.1	1.41×10^1	[13.9, 14.3]
13	0.286	2.86×10^{-1}	[0.284, 0.288]
14	120	1.20×10^2	[118, 122]
15	2.15	2.15×10^0	[2.13, 2.17]
16	6.92	6.92×10^0	[6.90, 6.94]
17	12.2	1.22×10^1	[12.0, 12.4]
18	0.00371	3.71×10^{-3}	[0.00369, 0.00373]
19	2.71 hrs	2.71×10^0	[2.69, 2.73]
20	728 m ²	7.28×10^2	[726, 730]
21	27.5	2.75×10^1	[27.3, 27.7]
22	21.2	2.12×10^1	[21.0, 21.4]
23	0.0280	2.80×10^{-2}	[0.0278, 0.0282]
24	62.4	6.24×10^1	[62.2, 62.6]
25	4.13	4.13×10^0	[4.11, 4.15]
26	19.0	1.90×10^1	[18.8, 19.2]
27	6.09	6.09×10^0	[6.07, 6.11]
28	18.4	1.84×10^1	[18.2, 18.6]
29	110 min	1.10×10^2	[108, 112]
30	76.0 deg	7.60×10^1	[75.8, 76.2]
31	1.19	1.19×10^0	[1.17, 1.21]
32	0.731	7.31×10^{-1}	[0.729, 0.733]
33	6.29	6.29×10^0	[6.27, 6.31]
34	0.860	8.60×10^{-1}	[0.858, 0.862]
35	6.64	6.64×10^0	[6.62, 6.66]

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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	0.0707	7.07×10^{-2}	[0.0705, 0.0709]
37	1.44	1.44×10^0	[1.42, 1.46]
38	0.999	9.99×10^{-1}	[0.997, 1.00]
39	19.1 g	1.91×10^1	[18.9, 19.3]
40	111 m	1.11×10^2	[109, 113]
41	1.74	1.74×10^0	[1.72, 1.76]
42	59.3	5.93×10^1	[59.1, 59.5]
43	3.12	3.12×10^0	[3.10, 3.14]
44	0.976	9.76×10^{-1}	[0.974, 0.978]
45	0.619	6.19×10^{-1}	[0.617, 0.621]
46	5.95	5.95×10^0	[5.93, 5.97]
47	1.52	1.52×10^0	[1.50, 1.54]
48	131	1.31×10^2	[129, 133]
49	51.9 cm	5.19×10^1	[51.7, 52.1]
50	329 m ²	3.29×10^2	[327, 331]
51	203490 [INT]	2.03×10^5	[203490]
52	3603600 [INT]	3.60×10^6	[3603600]
53	17.0	1.70×10^1	[16.8, 17.2]
54	40.2	4.02×10^1	[40.0, 40.4]
55	3.27	3.27×10^0	[3.25, 3.29]
56	1.76	1.76×10^0	[1.74, 1.78]
57	8.00	8.00×10^0	[7.98, 8.02]
58	3.35	3.35×10^0	[3.33, 3.37]
59	3.71×10^3 cm ³	3.71×10^3	[3.69, 3.73] $\times 10^3$
60	1.32×10^4 cm ³	1.32×10^4	[1.30, 1.34] $\times 10^4$
61	14.2	1.42×10^1	[14.0, 14.4]
62	0.232	2.32×10^{-1}	[0.230, 0.234]
63	0.682	6.82×10^{-1}	[0.680, 0.684]
64	1.43	1.43×10^0	[1.41, 1.45]
65	3.21	3.21×10^0	[3.19, 3.23]
66	4.80	4.80×10^0	[4.78, 4.82]
67	6.90	6.90×10^0	[6.88, 6.92]
68	16.5	1.65×10^1	[16.3, 16.7]
69	1.01×10^3 in ³	1.01×10^3	[992, 1.03×10^3]
70	905 m	9.05×10^2	[903, 907]

STACKCALC32 RPM BENCHMARK: 580 KEYSTROKES vs. 1175 ALGEBRAIC (SAVING 595 KEYS, 50.6% 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: \$96.99**

A digital storage oscilloscope priced at \$112.00 is discounted by 20%. With 8.25% state sales tax applied to the discounted price, calculate the total final 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: [112] [ENTER] [0.80] [$\times$] [1.0825] [$\times$] -> \$96.99

PROBLEM 10 • 3D PRINTING FILAMENT & LINEAR DENSITY**ANSWER: 1.41×10^3 m**

High-conductivity bronze 3D printing filament weighs 4.12 grams per linear meter. How many meters of filament are wound onto a 5.80 kilogram commercial 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: [5.8] [ENTER] [1000] [$\times$] [4.12] [$\div$] -> 1.41×10^3 m

PROBLEM 19 • PARALLEL PROCESSING & VACUUM CHAMBER EVACUATION**ANSWER: 2.71 hrs**

In an automated vacuum chamber for degassing 3D printing silicone molds, primary vacuum line A evacuates the tank in 4.50 hours, while auxiliary pump line B requires 6.80 hours. How many hours will it take to evacuate the tank if both pumps operate together?

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: [4.5] [$1/x$] [6.8] [$1/x$] [$+$] [$1/x$] -> 2.71 hrs

PROBLEM 20 • TURNTABLE FLANGE & COMMUTATOR RING AREA**ANSWER: 728 m²**

A circular 3D printed mechanical turntable ring has an inside opening radius of 23.5 meters bordered by an exterior mounting flange extending out to a radius of 28.0 meters. Calculate the surface area of the flange 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: [28] [$\times^2$] [23.5] [$\times^2$] [$-$] [π] [$\times$] -> 728 m²

PROBLEM 29 • LASER GANTRY TRIANGULATION & VERTICAL MAST HEIGHT**ANSWER: 110 min**

Two mobile modular robotics test platforms separated by 64.0 miles travel directly toward each other with ground speeds of 15.2 mph and 19.8 mph. In how many minutes will they pass each other?

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: [64] [ENTER] [15.2] [ENTER] [19.8] [+] [+] [60] [×] → 110 min

PROBLEM 30 • SMD PLACEMENT MACHINE PRODUCTION RATE & PROPORTION**ANSWER: 76.0 deg**

An articulated pick-and-place camera boom 38.0 feet long leans against a vertical electronics rack with its ground base resting 9.20 feet away from the foundation. Determine the acute angle in degrees between the boom and the horizontal ground.

GOVERNING MODEL: Placed Components = (Rate per Minute) × Total Time

NUMERICAL SETUP: 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] [9.2] [ENTER] [38] [+] [ACOS] → 76.0 deg

PROBLEM 39 • SENSOR CALIBRATION & EXPONENTIAL RADIOACTIVE DECAY**ANSWER: 19.1 g**

A radioactive calibration source for an electronic radiation monitor has a disintegration half-life of 16.8 days. If a test specimen initially contains 120.0 grams of the active isotope, what mass in grams remains active after 44.5 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: [44.5] [ENTER] [16.8] [÷] [0.5] [x<>y] [y^x] [120] [×] → 19.1 g

PROBLEM 40 • LASER GANTRY TRIANGULATION & VERTICAL MAST HEIGHT**ANSWER: 111 m**

From calibration point P on a level test bed, the angle of elevation to an optical sensor mast is 38.5°. Advancing 54.0 meters directly toward the mast to point Q, the angle of elevation is 52.4°. Determine the height of the mast 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] [38.5] [TAN] [1/x] [52.4] [TAN] [1/x] [-] [1/x] [54] [×] → 111 m

PROBLEM 49 • RIGHT TRIANGLE TRIGONOMETRY**ANSWER: 51.9 cm**

RIGHT TRIANGLE: In the right triangle shown below, hypotenuse $c = 78.4$ cm and acute angle $\theta = 41.5^\circ$. Calculate the length of opposite side a .

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

NUMERICAL SETUP: $a = 78.4 \times \sin(41.5^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

In a right triangle, the opposite leg equals hypotenuse c multiplied by $\sin(\theta)$. With $c = 78.4$ and acute angle $\theta = 41.5^\circ$, calculate in Degree mode and round non-integers to 3 significant figures.

CALCULATOR FLOW: [DEG] [78.4] [ENTER] [41.5] [SIN] [×] → 51.9 cm

PROBLEM 50 • CIRCULAR SECTOR AREA**ANSWER: 329 m²**

CIRCULAR SECTOR: For the circular sector diagrammed below, radius $r = 22.5$ m and central angle $\theta = 74.5^\circ$. 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: $\text{Area} = \pi \times (22.5)^2 \times (74.5^\circ / 360^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

A circular sector represents a fraction $(\theta / 360^\circ)$ of a full circle. Square radius $r = 22.5$, multiply by angle $\theta = 74.5^\circ$, multiply by π , and divide by 360.

CALCULATOR FLOW: [22.5] [x²] [74.5] [×] [π] [×] [360] [÷] → 329 m²

PROBLEM 59 • RIGHT CIRCULAR CONE VOLUME**ANSWER: 3.71 × 10³ cm³**

RIGHT CIRCULAR CONE: The solid cone shown has base radius $r = 11.5$ cm and vertical height $h = 26.8$ cm. Calculate the volume of the cone in cubic centimeters.

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

NUMERICAL SETUP: $V = (1/3) \times \pi \times (11.5)^2 \times (26.8)$

STEP-BY-STEP MATHEMATICAL REASONING:

The cone volume equals one-third base area times vertical height. Square base radius $r = 11.5$, multiply by vertical height $h = 26.8$, multiply by π , and divide by 3.

CALCULATOR FLOW: [11.5] [x²] [26.8] [×] [π] [×] [3] [÷] → 3.71 × 10³ cm³

PROBLEM 60 • CONICAL FRUSTUM VOLUME**ANSWER: 1.32 × 10⁴ cm³**

CONICAL FRUSTUM: A truncated cone has lower base radius $R = 17.5$ cm, upper base radius $r = 9.40$ cm, and vertical height $h = 22.5$ 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: $V = (1/3) \times \pi \times 22.5 \times [(17.5)^2 + (17.5)(9.4) + (9.4)^2]$

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 22.5, multiply by π , and divide by 3.

CALCULATOR FLOW: [17.5] [x²] [17.5] [ENTER] [9.4] [×] [+] [9.4] [x²] [+] [22.5] [×] [π] [×] [3] [÷] → 1.32 × 10⁴ cm³

PROBLEM 69 • CALCULUS OPTIMIZATION: MODULAR ELECTRONICS ENCLOSURE**ANSWER: $1.01 \times 10^3 \text{ in}^3$**

A 3D printed modular electronics enclosure with an open top and square base is constructed from 480 square inches of polymer sheet. Using calculus optimization, determine the maximum theoretical volume of the box 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: [160] [√x] [80] [×] -> $1.01 \times 10^3 \text{ in}^3$

PROBLEM 70 • TACTILE KEY SWITCH EJECTION DYNAMICS & KINEMATICS**ANSWER: 905 m**

In an automated drop-and-ejection test rig for mechanical switches, a key switch stem is launched from ground level with launch velocity $v_0 = 94.5 \text{ m/s}$ at an elevation angle of 42.0° above horizontal. Taking gravitational acceleration $g = 9.81 \text{ m/s}^2$, determine the horizontal flight range in meters.

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

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/s^2 .

CALCULATOR FLOW: [DEG] [94.5] [x^2] [42] [ENTER] [2] [×] [SIN] [×] [9.81] [÷] -> 905 m