

2026 TAPPS HIGH SCHOOL CALCULATOR APPLICATIONS STATE CHAMPIONSHIP EXAM – OFFICIAL ANSWERS

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	30.9	3.09×10^1	[30.7, 31.1]
2	168	1.68×10^2	[166, 170]
3	23.6	2.36×10^1	[23.4, 23.8]
4	5.15	5.15×10^0	[5.13, 5.17]
5	0.0382	3.82×10^{-2}	[0.0380, 0.0384]
6	91.3	9.13×10^1	[91.1, 91.5]
7	7.21	7.21×10^0	[7.19, 7.23]
8	714	7.14×10^2	[712, 716]
9	\$1109.56	1.11×10^3	[1.09, 1.13] $\times 10^3$
10	1.43×10^3 m	1.43×10^3	[1.41, 1.45] $\times 10^3$
11	1.11	1.11×10^0	[1.09, 1.13]
12	18.9	1.89×10^1	[18.7, 19.1]
13	0.231	2.31×10^{-1}	[0.229, 0.233]
14	202	2.02×10^2	[200, 204]
15	2.33	2.33×10^0	[2.31, 2.35]
16	8.50	8.50×10^0	[8.48, 8.52]
17	14.5	1.45×10^1	[14.3, 14.7]
18	0.00170	1.70×10^{-3}	[0.00168, 0.00172]
19	3.87 hrs	3.87×10^0	[3.85, 3.89]
20	2.42×10^3 m ²	2.42×10^3	[2.40, 2.44] $\times 10^3$
21	36.2	3.62×10^1	[36.0, 36.4]
22	31.7	3.17×10^1	[31.5, 31.9]
23	0.00958	9.58×10^{-3}	[0.00956, 0.00960]
24	84.0	8.40×10^1	[83.8, 84.2]
25	4.30	4.30×10^0	[4.28, 4.32]
26	7.01	7.01×10^0	[6.99, 7.03]
27	6.93	6.93×10^0	[6.91, 6.95]
28	23.7	2.37×10^1	[23.5, 23.9]
29	111 min	1.11×10^2	[109, 113]
30	76.1 deg	7.61×10^1	[75.9, 76.3]
31	1.05	1.05×10^0	[1.03, 1.07]
32	1.27	1.27×10^0	[1.25, 1.29]
33	6.70	6.70×10^0	[6.68, 6.72]
34	0.762	7.62×10^{-1}	[0.760, 0.764]
35	11.3	1.13×10^1	[11.1, 11.5]

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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	0.0174	1.74×10^{-2}	[0.0172, 0.0176]
37	1.27	1.27×10^0	[1.25, 1.29]
38	1.00	1.00×10^0	[0.998, 1.00]
39	30.6 mg	3.06×10^1	[30.4, 30.8]
40	154 m	1.54×10^2	[152, 156]
41	1.99	1.99×10^0	[1.97, 2.01]
42	60.2	6.02×10^1	[60.0, 60.4]
43	5.71	5.71×10^0	[5.69, 5.73]
44	0.993	9.93×10^{-1}	[0.991, 0.995]
45	0.385	3.85×10^{-1}	[0.383, 0.387]
46	4.89	4.89×10^0	[4.87, 4.91]
47	1.30	1.30×10^0	[1.28, 1.32]
48	25.0	2.50×10^1	[24.8, 25.2]
49	71.4 cm	7.14×10^1	[71.2, 71.6]
50	657 m ²	6.57×10^2	[655, 659]
51	3268760 [INT]	3.27×10^6	[3268760]
52	13366080 [INT]	1.34×10^7	[13366080]
53	22.6	2.26×10^1	[22.4, 22.8]
54	166	1.66×10^2	[164, 168]
55	12.3	1.23×10^1	[12.1, 12.5]
56	2.44	2.44×10^0	[2.42, 2.46]
57	9.73	9.73×10^0	[9.71, 9.75]
58	3.65	3.65×10^0	[3.63, 3.67]
59	8.23×10^3 cm ³	8.23×10^3	[8.21, 8.25] $\times 10^3$
60	3.51×10^4 cm ³	3.51×10^4	[3.49, 3.53] $\times 10^4$
61	18.4	1.84×10^1	[18.2, 18.6]
62	0.246	2.46×10^{-1}	[0.244, 0.248]
63	0.659	6.59×10^{-1}	[0.657, 0.661]
64	1.76	1.76×10^0	[1.74, 1.78]
65	3.52	3.52×10^0	[3.50, 3.54]
66	5.24	5.24×10^0	[5.22, 5.26]
67	14.8	1.48×10^1	[14.6, 15.0]
68	57.9	5.79×10^1	[57.7, 58.1]
69	1.86×10^3 in ³	1.86×10^3	[1.84, 1.88] $\times 10^3$
70	1.41×10^3 m	1.41×10^3	[1.39, 1.43] $\times 10^3$

STACKCALC32 RPM BENCHMARK: 589 KEYSTROKES vs. 879 ALGEBRAIC (SAVING 290 KEYS, 33.0% 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: \$1109.56**

A digital electronics laboratory purchases a 4-channel mixed-signal oscilloscope originally priced at \$1,250.00 with an 18% educational discount. If state sales tax is 8.25%, 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: [1250] [ENTER] [0.82] [$\times$] [1.0825] [$\times$] -> \$1109.56

PROBLEM 10 • 3D PRINTING FILAMENT & LINEAR DENSITY**ANSWER: 1.43×10^3 m**

Conductive copper-infused 3D printing filament weighs 6.45 grams per meter. How many meters of filament are wound onto a 9.20 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: [9.2] [ENTER] [1000] [$\times$] [6.45] [$\div$] -> 1.43×10^3 m

PROBLEM 19 • PARALLEL PROCESSING & VACUUM CHAMBER EVACUATION**ANSWER: 3.87 hrs**

In an automated vacuum chamber for degassing 3D printing silicone molds, primary vacuum line A evacuates the tank in 6.40 hours and auxiliary pump line B requires 9.80 hours. In how many hours will the tank evacuate if both lines operate 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: [6.4] [$1/x$] [9.8] [$1/x$] [+] [$1/x$] -> 3.87 hrs

PROBLEM 20 • TURNTABLE FLANGE & COMMUTATOR RING AREA**ANSWER: 2.42×10^3 m²**

A 3D printed circular speaker grille bezel has an inner circular opening radius of 31.5 meters and an outer perimeter radius of 42.0 meters. Calculate the surface area of the circular border ring 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: [42] [$\times^2$] [31.5] [$\times^2$] [-] [π] [$\times$] -> 2.42×10^3 m²

PROBLEM 29 • AUTONOMOUS ROBOTICS & AGV KINEMATICS**ANSWER: 111 min**

Two autonomous robotic parts shuttles in an electronics cleanroom separated by 94.0 miles travel toward each other at steady velocities of 22.5 mph and 28.5 mph. In how many minutes will they pass each other?

GOVERNING MODEL: Closing Speed = $v_1 + v_2$; Time = Distance / Closing Speed

NUMERICAL SETUP: $t = \text{Distance} / (v_1 + v_2)$ [or Separation = $(v_1 + v_2) \times t$]

STEP-BY-STEP MATHEMATICAL REASONING:

For autonomous robotic shuttles or gantry carriages moving relative to each other, closing velocity is $v_{\text{rel}} = v_1 + v_2$. Divide initial distance by closing speed to find encounter time, or multiply combined speed by time for separation distance.

CALCULATOR FLOW: [94] [ENTER] [22.5] [ENTER] [28.5] [+] [+] [60] [×] -> 111 min

PROBLEM 30 • ARTICULATED BOOM ANGLE OF INCLINE**ANSWER: 76.1 deg**

An articulated camera inspection boom on an automated PCB assembly line is 52.0 feet long with its footing positioned 12.5 feet from the vertical mounting rail. What acute angle in degrees does the boom form with the horizontal floor?

GOVERNING MODEL: $\cos(\theta) = \text{Base} / \text{Length} \Rightarrow \theta = \arccos(\text{Base} / \text{Length})$

NUMERICAL SETUP: $\theta = \arccos(\text{Distance_to_Pivot} / \text{Boom_Length})$

STEP-BY-STEP MATHEMATICAL REASONING:

The articulated camera boom forms a right triangle with the base plane. Horizontal offset is adjacent to θ while boom length is hypotenuse: $\cos(\theta) = \text{Base} / \text{Length}$. Evaluate arccos in Degree mode.

CALCULATOR FLOW: [DEG] [12.5] [ENTER] [52] [÷] [ACOS] -> 76.1 deg

PROBLEM 39 • SENSOR CALIBRATION & EXPONENTIAL RADIOACTIVE DECAY**ANSWER: 30.6 mg**

An electronic timing sensor's radioactive calibration source decays with a clearance half-life of 22.5 hours. If an initial activity of 220.0 mg is administered, what mass in milligrams remains active after 64.0 hours?

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: [64] [ENTER] [22.5] [÷] [0.5] [x<>y] [y^x] [220] [×] -> 30.6 mg

PROBLEM 40 • LASER GANTRY TRIANGULATION & VERTICAL MAST HEIGHT**ANSWER: 154 m**

An optical laser triangulation sensor measures the vertical height of a 3D printer gantry tower. From calibration station P on level ground, the angle of elevation to the tower apex is 38.5°. Moving 75.0 meters closer to station Q, the elevation angle increases to 52.4°. Find the vertical height of the 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] [38.5] [TAN] [1/x] [52.4] [TAN] [1/x] [-] [1/x] [75] [×] -> 154 m

PROBLEM 49 • RIGHT TRIANGLE TRIGONOMETRY**ANSWER: 71.4 cm**

RIGHT TRIANGLE: In the right triangle diagrammed below, hypotenuse $c = 98.5$ cm and acute angle $\theta = 46.5^\circ$. Find the length of leg a in centimeters.

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

NUMERICAL SETUP: $a = 98.5 \times \sin(46.5^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

In a right triangle, the opposite leg equals hypotenuse c multiplied by $\sin(\theta)$. With $c = 98.5$ and acute angle $\theta = 46.5^\circ$, calculate in Degree mode and round non-integers to 3 significant figures.

CALCULATOR FLOW: [DEG] [98.5] [ENTER] [46.5] [SIN] [×] -> 71.4 cm

PROBLEM 50 • CIRCULAR SECTOR AREA**ANSWER: 657 m²**

CIRCULAR SECTOR: For the circular sector below, radius $r = 29.5$ m and central angle $\theta = 86.5^\circ$. Calculate the area of the sector in square meters.

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

NUMERICAL SETUP: $\text{Area} = \pi \times (29.5)^2 \times (86.5^\circ / 360^\circ)$

STEP-BY-STEP MATHEMATICAL REASONING:

A circular sector represents a fraction $(\theta / 360^\circ)$ of a full circle. Square radius $r = 29.5$, multiply by angle $\theta = 86.5^\circ$, multiply by π , and divide by 360.

CALCULATOR FLOW: [29.5] [x²] [86.5] [×] [π] [×] [360] [÷] -> 657 m²

PROBLEM 59 • RIGHT CIRCULAR CONE VOLUME**ANSWER: 8.23 × 10³ cm³**

RIGHT CIRCULAR CONE: The cone shown has base radius $r = 15.2$ cm and height $h = 34.0$ cm. Calculate its volume in cubic centimeters.

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

NUMERICAL SETUP: $V = (1/3) \times \pi \times (15.2)^2 \times (34.0)$

STEP-BY-STEP MATHEMATICAL REASONING:

The cone volume equals one-third base area times vertical height. Square base radius $r = 15.2$, multiply by vertical height $h = 34.0$, multiply by π , and divide by 3.

CALCULATOR FLOW: [15.2] [x²] [34.0] [×] [π] [×] [3] [÷] -> 8.23 × 10³ cm³

PROBLEM 60 • CONICAL FRUSTUM VOLUME**ANSWER: 3.51 × 10⁴ cm³**

CONICAL FRUSTUM: A truncated cone has bottom radius $R = 24.0$ cm, top radius $r = 13.5$ cm, and height $h = 31.0$ cm. Find the volume in cubic centimeters.

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

NUMERICAL SETUP: $V = (1/3) \times \pi \times 31.0 \times [(24.0)^2 + (24.0)(13.5) + (13.5)^2]$

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 31.0, multiply by π , and divide by 3.

CALCULATOR FLOW: [24.0] [x²] [24.0] [ENTER] [13.5] [×] [+] [13.5] [x²] [+] [31.0] [×] [π] [×] [3] [÷] -> 3.51 × 10⁴ cm³

PROBLEM 69 • CALCULUS OPTIMIZATION: MODULAR ELECTRONICS ENCLOSURE**ANSWER: $1.86 \times 10^3 \text{ in}^3$**

A 3D printed modular electronics enclosure with an open top and square base is constructed from 720 square inches of polymer sheet. 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: [240] [√x] [120] [×] -> $1.86 \times 10^3 \text{ in}^3$

PROBLEM 70 • TACTILE KEY SWITCH EJECTION DYNAMICS & KINEMATICS**ANSWER: $1.41 \times 10^3 \text{ m}$**

In an automated drop-and-ejection test rig for mechanical keyboard switches, a spring-driven switch stem is propelled from level ground with initial velocity $v_0 = 118.0 \text{ m/s}$ at an elevation angle of 42.0° above horizontal. With gravitational acceleration $g = 9.81 \text{ m/s}^2$, determine the horizontal trajectory 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] [118] [x^2] [42] [ENTER] [2] [×] [SIN] [×] [9.81] [÷] -> $1.41 \times 10^3 \text{ m}$