Science Olympiad
Golden Gate Invitational
January 31, 2026

Machines C Answer Key

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Section A [42 points]

1. (a) [3 pts] 2.88

   (b) [7 pts] $2.97\,\mathrm{s}$

2. (a) [2 pts] $323\,\mathrm{W}$

   (b) [3 pts] $0.854\,\mathrm{N\,m}$

3. (a) [1 pt] Class 1

   (b) [4 pts] 7.91 (Partial credit for 7.51)

4. (a) [2 pts] The tension on the upper lever arms does not counteract the weight of the mass.

   (b) [3 pts] 16

   (c) [5 pts] Place the heavier mass on the upper beam, $60\,\mathrm{cm}$ from the fulcrum, and the lighter mass on the lower beam, $37.5\,\mathrm{cm}$ from the fulcrum. This gives a worst-case percent error of $0.434\,\%$.

   Note that placing the heavier mass $40\,\mathrm{cm}$ and the lighter mass $25\,\mathrm{cm}$ from the fulcrum gives a worst-case percent error of $0.652\,\%$.

5. (a) [2 pts] 4 teeth

   (b) [3 pts] $14\,\mathrm{rps}$, same direction

   (c) [5 pts] 0.752 (Partial credit for 0.797)

6. [2 pts] Round dry sand, angular dry sand, gravel, wet sand

Section B [58 points]

7. (a) [2 pts] Hollow cylinder, hollow ball, disk, solid ball

   (b) [2 pts] Same time

   (c) [5 pts] Object: $a/\sqrt{b}$
   Hollow cylinder: $1/\sqrt{2}$
   Hollow ball: $2/\sqrt{15}$
   Disk: $1/\sqrt{6}$
   Solid ball: $2/\sqrt{35}$

8. [8 pts] $21.4°$, counterclockwise

9. [6 pts] $F_{\mathrm{A},x} = 150\,\mathrm{N}$ (right), $F_{\mathrm{A},y} = 1515\,\mathrm{N}$ (down), $F_{\mathrm{B},x} = 150\,\mathrm{N}$ (left), $F_{\mathrm{B},y} = 584\,\mathrm{N}$ (up)

10. [4 pts] $2.34\,\mathrm{kg}$

11. [8 pts] $4.12\,\mathrm{m/s^2}$ (down)

12. [5 pts] $39.0\,\mathrm{rad/s^2}$

13. (a) [5 pts] $34.6\,\mathrm{cm}$

    (b) [3 pts] $\sqrt{(3/2)(g/l)}$

14. (a) [4 pts] $\ell\mu/\sqrt{1+\mu^2}$

    (b) [6 pts] m: $0.205g$ (right), M: $0.355g$ (down)