Science Olympiad
MIT Invitational
January 24, 2026

Machines C Answer Key

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Section A [70 points]

1. D	2. B	3. C	4. B	5. A
6. C	7. B	8. A	9. B	10. C
11. B	12. A	13. B	14. A	15. B
16. D	17. C	18. C	19. B	20. D
21. C	22. C	23. D	24. C	25. B
26. C	27. E	28. A, D	29. C, E	30. B, E
31. B	32. B, C	33. B, C	34. E	35. D

Section B [80 points]

For compute questions, half points are given for work shown, and the other half for the correct answer.

1. (a) [2 pts] 4
   (b) [3 pts] 0.118 [0.112, 0.124]
   (c) [3 pts] 2210 N [2150, 2270]
   (d) [2 pts] Remain the same (1); truck's velocity and tension of the cable have a constant product, since increased IMA would increase velocity of table and decrease tension by the same factor (1)

2. (a) [3 pts] 0.224 [0.221, 0.227]
   (b) [3 pts] 17.9 m/s [17.4, 18.4]
   (c) [4 pts] 71.3 J [70.6, 72.0] (4) OR 57.0 J [56.3, 57.7] (3)

3. (a) i. [1 pt] Class III
      ii. [2 pts] 0.124 (Exact)
   (b) [3 pts] 9.66° [9.47, 9.85]
   (c) [3 pts] 13.8° [13.5, 14.1]
   (d) [4 pts] 0.336 N [0.322, 0.350]
   (e) i. [1 pt] 16.1° [15.8, 16.4]
      ii. [3 pts] 14.7° [14.4, 15.0]
      iii. [3 pts] 1.26 m/s [1.21, 1.31]

4. (a) [2 pts] $M_D = 7/3$ bvr (Exact)
   (b) [2 pts] $M_B = 2/3$ bvr (Exact)
   (c) [3 pts] M_B can take on any mass (1). M_C is in equilibrium with M_D, so $M_C \leq 1/2$ bvr (1). Then, $M_E + M_F \leq 1/4$ bvr (0.5) and torque balance means $2M_E = M_F$ (0.5).
   (d) i. [5 pts] $M_{\max/\min} = (19 \pm \sqrt{345})/8$
      ii. [5 pts] $a_A = 1.75\,\text{m/s}^2$ (Upwards (0.5); [1.71, 1.79] (2)),
      $a_E = -6.72\,\text{m/s}^2$ (Downwards (0.5); [6.68, 6.75] (2))
      iii. [3 pts] 6.86 W [6.79, 6.93]
   (e) [0 pts] Tim the beaver

5. (a) [1 pt] Left
   (b) [2 pts] $Mg/4$
   (c) [2 pts] $g\mu/2$
   (d) [4 pts] $\tau_{\text{axle}}(\theta) = \kappa\theta\frac{r}{L}\sec\left[\frac{\theta}{2} + \sin^{-1}\left(\frac{r}{2L}\csc\left[\frac{\pi-\theta}{2}\right]\right)\right]$
   (e) [3 pts] 148° [146, 150]
   (f) [6 pts] $\Delta d = 2.00\,\text{m}$ [1.98, 2.02] (6) OR 1.95 m [1.93, 1.97] (3)
   (g) [2 pts] No (1). Since the angles in part (f) are less than the critical angle from part (c), the vehicle moves without slipping (1). The number of rotations of the right wheels doesn't change and thereby the distance traveled does not as well.