Section A (60 points)

1.   E

2.   A

3.   A

4.   D

5.   A

6.   B

7.   B

8.   E

9.   D

10.   D

11.   B

12.   C

13.   C

14.   A, E

15.   C

16.   C

17.   B

18.   B

19.   B

20.   A

21.   B

22.   B

23.   D

24.   B

25.   C

26.   C

27.   D

28.   E

29.   C

30.   C

Section B (90 points)

1. (a) <u>Wheel and axle</u>

   (b) <u>Allows for higher speed of travel. Smoother ride on rough surfaces. etc.</u>

   (c) i. <u>$d/2R$</u>

   ii. <u>$F_R + F_r = W$</u> **[1.5]**

   <u>$aF_R = bF_r$</u> **[1.5]**

   iii. <u>$F_R = bW/(a+b)$</u> **[1.5]**

   <u>$F_r = aW/(a+b)$</u> **[1.5]**

   iv. <u>$d/2R - 5Wc_l/3RF_{in}$</u>

   v. <u>Descent: $\tan^{-1}(a/h)$</u> **[2]**

   <u>Ascent: $\tan^{-1}(b/h)$</u> **[2]**

2. (a) i. <u>20.9</u>

   ii. <u>19.6</u>

   iii. <u>2.81 cm</u>

   (b) i. <u>Class 1</u>

   ii. <u>3.60</u>

   iii. <u>0.344</u>

   iv. <u>0.207 s</u>

   v. <u>40 cm</u> **[4]**

   <u>All potential energy from the disk is used to move the block, all forces (tension, push on block) are perpendicular to the ground as the lever's angular displacement is small, all components are at rest immediately after the disk hits the ground, etc.</u>

   [2 for appropriate assumptions]

   (c) i. <u>Class 2</u>

   ii. <u>0.805 cm</u>

   iii. <u>0.134 cm</u>

3. <u>Rubric outlined in solutions.</u>

4. (a) <u>2 or 1/2</u>

   (b) <u>$8.08 \, \mathrm{m\,s^{-2}}$</u>

   <u>Downwards</u>

   (c) M: <u>45.4 kg</u>

   μ: <u>14.6 kg</u>

   (d) <u>105 N</u>