Answers to Mid-Year Exam

MCQ

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	**B**	**C**	**C**	**D**	**D**	**C**	**D**	**A**	**D**
Q11	Q12	Q13	Q14	Q15					
C	**A**	**B**	**B**	**B**					

Structure Questions

1 **(a)** $6\pi\eta r v^2 = \frac{4}{3}\pi r^3(\rho - \rho_L)g$

Units of left hand side: (kg m^{-1} s^{-1}) (m) (m s^{-1})^2 = (kg m^2 s^{-3}) **[M1]**
Units of right hand side: (m^3) (kg m^{-3}) (m s^{-2}) = (kg m s^{-2}) **[M1]**
Since the units for left and right hand sides are not equal, the equation is not correct. **[A1]**

(Comments: Students need to be more mindful of the presentation of their answers. They should not include physical quantities in equations that consist of units as well. In addition, students should write a statement to conclude whether the equation is physically correct.)

(b) **(i)** Irregularities in diameter of sphere. **[A1]**

(Comments: Students need to explain clearly the type of random error involved, instead of merely stating a generic and insignificant error.)

(ii) Measure the diameter along different orientations of the sphere and take average. **[A1]**

(Comments: The improvement stated should be linked to the random error stated in (b)(i) and it should be explained clearly.)

(iii) $F = Br^2\rho v^2$

$$B = \frac{F}{r^2\rho v^2}$$

$$B = \frac{8\times10^{-3}}{(0.03)^2(1000)(0.24)^2}$$

= 0.15432 **[C1]**

$$\frac{\Delta B}{B} = \frac{\Delta F}{F} + 2(\frac{\Delta r}{r}) + \frac{\Delta\rho}{\rho} + 2(\frac{\Delta v}{v})$$

$$\frac{\Delta B}{0.15432} = \frac{0.1}{8.0} + 2(\frac{0.1}{3.0}) + \frac{0.01}{1.00} + 2(\frac{1}{24})$$ **[M1]**

$\Delta B = 0.15432 \times 0.1725 = 0.0266$

$B = 0.15 \pm 0.03$ **[A1]**

(Comments: Many students were careless with the conversion of units. The alternative correct method to solving this part of question is to calculate the maximum and minimum B and subsequently find ΔB.)

(iv) The measurement velocity gives rise to the greatest uncertainty in the value for B **[A1]**

because $2\left(\frac{\Delta v}{v}\right) = 0.08$ is the largest. **[M1]**

(*Comments: Many students did not get any credit, as they were not able to state a correct reason for choosing velocity as the answer. A large number of students were confused with the terms 'uncertainty' and 'fractional uncertainty'.)*

2 **(a)** **(i)** horizontal component = 63 cos 14° = 61.1 m s^{-1}
vertical component = 63 sin 14° = 15.2 m s^{-1} **[A1]**

(*Comments: Some answers in (i) had their horizontal and vertical components mixed up.)*

(ii) horizontal displacement = (63 cos 14°) (4.9) = 300 m **[A1]**

(iii) vertical displacement = (63 sin 14°)(4.9) – (0.5)(9.81)(4.9)^2 **[M1]**

= – 43 m **[A1]**

(*Comments: Some students substitute values into the equation of motion with no regard to the different direction between initial vertical velocity and the acceleration of free fall)*

(iv) tan θ = (43/300) **[M1]**

θ = 8.2° **[A1]**

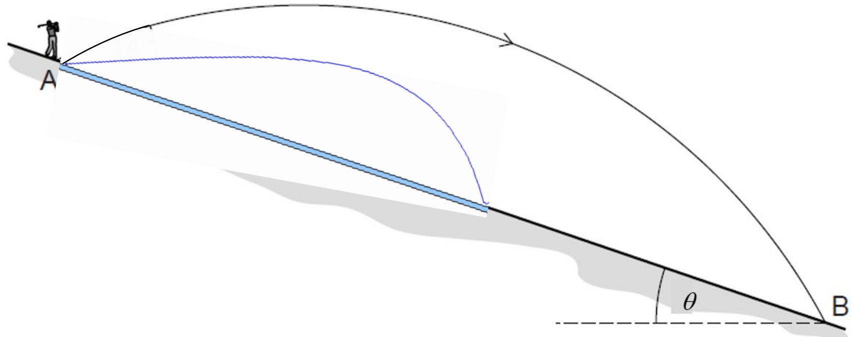
(*Comments: This is not the angle that the velocity at B makes with the horizontal)*

(v) Distance is the actual path travelled. **[B1]**

Displacement is the straight line between A and B or minimum distance between A and B. **[B1]**

(b) new path lower highest point, shorter range, asymmetrical, (larger angle at which ball hits ground)

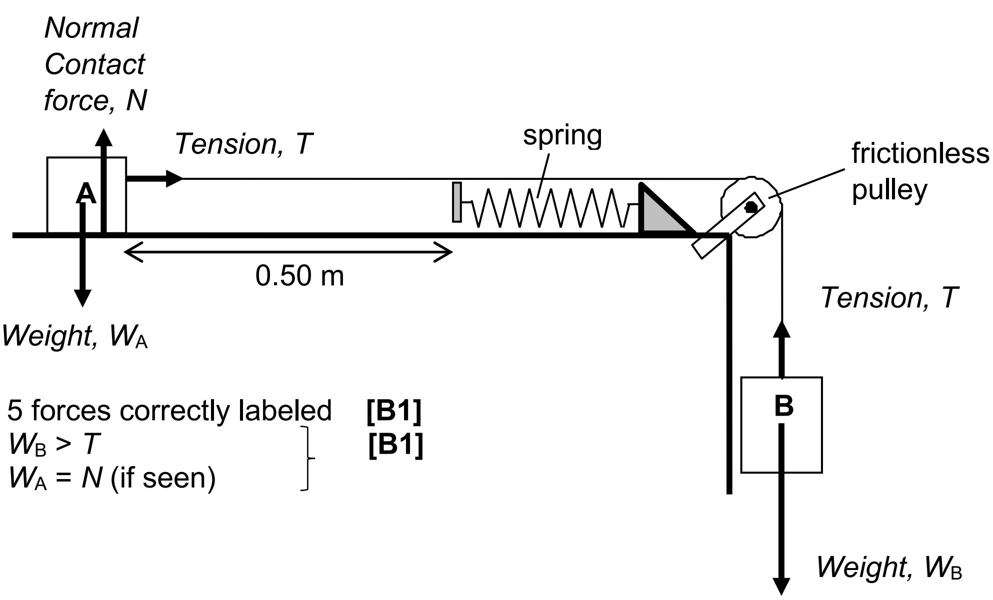
(Comments: Deduct one mark for each mistake)



3 **(a)** The rate of change of momentum of a body is proportional to the resultant force acting on the body and **[B1]**
occurs in the direction of the resultant force. **[B1]**

(Comments: For definitions, underlined keywords must be seen before marks are awarded.)

(b)



5 forces correctly labeled **[B1]**
$W_B > T$ **[B1]**
$W_A = N$ (if seen)

(Comments: A lot of candidates lose marks because they: (1) did not use ruler, (2) did not draw using the correct magnitude, (3) did not spell the forces in full. When the questions ask specifically to draw forces, the above criteria are applied by Cambridge's markers too.)

(c) Block A: $T = m_A\, a$ —— (1)

Block B: $W_B - T = m_B\, a$ —— (2)

(1) + (2): $W_B = (m_A + m_B)\, a$ **[B1]**

$0.50 \times 9.81 = (0.30 + 0.50)\, a$ **[B1]**

$a = 6.13 \text{ m s}^{-2}$ **[A0]**

(Comments: For "show" questions, all steps need to be clearly developed. All substitutions need to be shown, e.g. must show (0.3 + 0.5) rather than 0.8 directly. Candidates who write $W_B = (m_A + m_B)a$ directly without showing the two equations (1) and (2) above, are, by right, should not deserve the full credits. Due to leniency of marking, benefit of doubt is given to them. In future examinations, it is advisable to either formed two equations first as shown above, or write explicitly: "Applying F = ma to whole system, then write $W_B = (m_A + m_B)a$.)

(d) From (1): $T = 0.30 \times 6.131 = 1.84$ N **[A1]**

(Comments: Common mistakes: Some candidates thought that a = 9.81 ms^{-2}, ignoring the answer in the previous part.)

(e) Using $v^2 = u^2 + 2as$, $v^2 = 0 + 2\,(6.131)\,(0.50)$ **[C1]**

$v = 2.48 \text{ m s}^{-1}$ **[A1]**

(Comments: Common mistakes: Some candidates thought that a = 9.81 ms^{-2}, ignoring the answer in the previous part.)

(f) Using $v = u + at$, $2.476 = 0 + 6.131\, t$ **[C1]**

$t = 0.404$ s **[A1]**

(Comments: Common mistakes: Some candidates wrote time = distance/velocity, treating this as a constant velocity question, ignoring the fact that there is acceleration.)

(g) Resultant force = 0 N, acceleration is zero.

Block B: $W_B - T = 0$,

Block A: $T - F_{spring} = 0$

$0.50\,(9.81) - 360\,x = 0$ **[M1]**

$x = 0.0136$ m **[A1]**

(Comments: Common mistakes: A large number of candidates use tension = 1.84 N to try to solve this part, without realizing that the value of tension is different after the spring is compressed.)

(h) By conservation of energy,

$m_B gh = \frac{1}{2} k\, x_{max}^2$

$(0.50)(9.81)(0.50+x_{max}) = \frac{1}{2}(360)\, x_{max}^2$

$180\, x_{max}^2 - 4.905\, x_{max} - 2.4525 = 0$

$x_{max} = 0.131$ m

Alternatively,

$m_B gh + \frac{1}{2}(m_A+m_B)v^2 = \frac{1}{2} k\, x_{max}^2$ **[M1]**

$0.50(9.81)(x_{max}) + \frac{1}{2}(0.80)(2.48)^2$ **[M1]**

$= \frac{1}{2}(360)\, x_{max}^2$ **[A1]**

(Comments: Good to see that a good number of candidates try to use conservation of energy to solve. However, they are not aware that object B continues to lose gravitational potential energy as the spring is being compressed.)

4 **(a)** **(i)** **1.**

mass = density × volume **C1**

$= 920 \times 6.4 \times 10^4 \times (28 + d)$ **A1**

2.

either $920 \times 6.4 \times 10^4 \times (28 + d)$

or $1030 \times 6.4 \times 10^4 \times d$ **A1**

(Comments: The majority obtained the correct expressions. A few incorrectly quoted mass as ratio of density and volume. Some used the incorrect value of density in the required expression.)

(ii) $920 \times 6.4 \times 10^4 \times (28 + d) = 1030 \times 6.4 \times 10^4 \times d$ **C1**

$d = 234$ m **A1**

(Comments: A majority obtained the correct answer.)

(b) **(i)** Correct directions in both: to left in S_1, to right in S_2. **B1**

(Comments: A small number of students carelessly omitted this part of question.)

(ii) **1.** Moment = 150 × 0.3 = 45 N m **A1**

(Comments: Some students identified the wrong distance and used 0.12 m instead.)

2. Torque = 45 N m i.e. same as **1.** **A1**

(Comments: Students were encouraged to explain their working, rather than merely writing the answer as 45 N m.)

3. 45 = 0.12 × T **C1**
T = 375 N **A1**

(Comments: Some students substituted 0.06 m as the distance instead, without understanding the meaning of torque.)

5

(a) Conservation of Energy

Decrease in Gravitational Potential Energy = Increase in Kinetic Energy

$mg(H-2r) = \frac{1}{2}mv^2$ where m is mass of roller coaster **[C1]**

$2mg(H-2r) = mv^2$

$v = \sqrt{2g(H-2r)}$ **[A1]**

(Comments: Some answers did not use the symbols in the question.)

(b) At top of the loop,

Resultant force provides centripetal force

$N + W = \frac{mv^2}{r}$ where N is normal contact force

W is weight of roller coaster

For minimum height H, the roller coaster is just in contact at top of loop, therefore N = 0 **[M1]**

$mg = \frac{mv^2}{r}$ **[M1]**

$mg = \frac{2mg(H-2r)}{r}$

$mgr = 2mgH - 4mgr$

$5mgr = 2mgH$

$H = \frac{5}{2}r$ **[A0]**

(Comments: Many students mistakenly think that at the highest point, v = 0, which contradicts their answers in (a))

(c) Assume frictionless surfaces or no drag forces. **[C1]**
(Comments: Do not accept vague answers such as loss of energy to the surrounding or due to no heat loss)

6 (a) (i) direction of force on a (small test) mass **[B1]**
or path in which a (small test) mass will move **[B1]**

(Comments: There were very few clear explanations.)

(ii) At surface of Earth, lines of force are radial. **[B1]**
Earth has large radius while height above surface of Earth is small, so lines are (approximately) parallel which means constant field strength **[B1]**

(Comments: Great majority did not make reference to field lines near Earth's surface and used equation for field strength instead. There were very few clear explanations.)

(b) (i) Work done per unit mass in bringing a small test mass from infinity to that point **[B1]**

(Comments: The definition had not been learned carefully by many students. Some mentioned Φ at a point is the gravitational potential energy per unit mass associated with a test mass at that point. However, the gravitational potential energy of two point masses should be first defined.)

(ii) Gravitational forces are attractive and potential is zero at infinity **[M1]**
Work got out in moving test mass from infinity to that point **[A1]**
(3 out of 3 points to score 2)

(Comments: Only a small number were able to provide an adequate explanation.)

(c) (i) point Y is closer to planet.
either potential decreases as distance from planet decreases or potential zero at infinity and X is closer to zero
or potential proportional to $-1/r$ & potential at Y more negative **[A1]**

(Comments: No credit is given for merely comparing the relative values of potential at X *and* Y*. How gravitational potential varies with distance from the centre of planet should be mentioned in deducing point* Y *is closer to the planet.)*

(ii) idea of $\Delta\phi + (1/2)v^2 = 0$ **[M1]**
i.e. $(\phi_Y - \phi_X) + (1/2)v^2 = 0$

$\Rightarrow (6.8 - 5.3) \times 10^7 = (1/2)v^2$

$v = 5.5 \times 10^3$ m s^{-1} **[A1]**

(Comments: Some calculated the correct answer.)

Path of projectile for Q2(b): (for teachers)