Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION 2012

APPLIED MATHEMATICS

ORDINARY LEVEL CHIEF EXAMINER'S REPORT

HIGHER LEVEL CHIEF EXAMINER'S REPORT

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1. General Introduction

1.1 The Syllabus

The syllabus for Ordinary Level and Higher Level in Applied Mathematics is set out in the *Rules and Programmes for Secondary Schools*. The syllabus is currently available on the website of the Department of Education and Skills (www.education.ie) It is located in the section: Publications → Syllabuses and Prescribed Material → Senior Cycle → *(Page 7)* Mathematics – Leaving Certificate Applied Mathematics Syllabus.

This syllabus has been in operation for over thirty years. Those parts of the syllabus which are printed in italics apply to the Higher Level only.

The Higher Level course includes the Ordinary Level course treated in greater depth.

Knowledge of the relevant parts of the Mathematics course is assumed.

1.2 The Examination

At Ordinary Level, the examination consists of one paper, comprising nine questions. Six questions must be answered correctly to obtain full marks. Each question carries 50 marks.

At Higher Level, the examination consists of one paper, comprising ten questions. Six questions must be answered correctly to obtain full marks. Each question carries 50 marks.

The duration of the examination at both levels is two hours thirty minutes.

This report should be read in conjunction with the examination papers and the marking schemes for 2012. These are available on the website of the State Examinations Commission at www.examinations.ie.

2. Ordinary Level

2.1 Introduction

The examination consists of one paper, comprising nine questions. Six questions must be answered correctly to obtain full marks. Each question carries 50 marks. The duration of the examination is two hours thirty minutes.

Table 1 below shows the total number of candidates and the number of candidates at Ordinary Level for each of the last five years. While the proportion at Ordinary Level is slightly higher in 2011 and 2012 than in the previous years, the numbers involved are small, and it may therefore not be appropriate to regard this as meaningful.

Year	Total number of candidates taking Applied Mathematics	Number of Ordinary Level candidates	Percentage of total Applied Mathematics cohort	Percentage of total Leaving Certificate cohort
2008	1395	107	7·7	0·20
2009	1446	113	7·8	0·21
2010	1329	116	8·7	0·21
2011	1427	153	10·7	0·28
2012	1490	146	9·8	0·28

Table 1: Number of Leaving Certificate candidates taking Applied Mathematics (Ordinary Level) 2008 − 2012

2.2 Performance of Candidates

Table 2 shows how the candidates performed, with a summary of the results of the examination for 2012.

Year	Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG	Total
2009	Number	22	12	7	11	9	8	7	5	4	8	8	6	6	0	113
	%	19·5	10·6	6·2	9·7	8·0	7·1	6·2	4·4	3·5	7·1	7·1	5·3	5·3	0·0	
2010	Number	29	11	16	9	8	12	7	1	3	1	4	7	6	2	116
	%	25·0	9·5	13·8	7·8	6·9	10·3	6·0	0·9	2·6	0·9	3·4	6·0	5·2	1·7	
2011	Number	39	12	13	12	16	10	10	11	9	5	2	5	7	2	153
	%	25·5	7·8	8·5	7·8	10·5	6·5	6·5	7·2	5·9	3·3	1·3	3·3	4·6	1·3	
2012	Number	42	13	18	7	14	15	7	2	7	5	6	5	5	0	146
	%	28·8	8·9	12·3	4·8	9·6	10·3	4·8	1·4	4·8	3·4	4·1	3·4	3·4	0	

Table 2: Summary of outcomes for Leaving Certificate Applied Mathematics (Ordinary Level) 2009 − 2012.

Table 3 below shows the breakdown of the 2012 results in Ordinary Level Applied Mathematics by gender.

Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG	Total
Number	42	13	18	7	14	15	7	2	7	5	6	5	5	0	146
%	28·8	8·9	12·3	4·8	9·6	10·3	4·8	1·4	4·8	3·4	4·1	3·4	3·4	0	
No. Female	22	4	6	3	3	7	1	1	1	3	0	1	0	0	52
% Female	42·3	7·7	11·5	5·8	5·8	13·5	1·9	1·9	1·9	5·8	0	1·9	0	0	
No. Male	20	9	12	4	11	8	6	1	6	2	6	4	5	0	94
% Male	21·3	9·6	12·8	4·3	11·7	8·5	6·4	1·1	6·4	2·1	6·4	4·3	5·3	0	

Table 3: Grade outcomes Leaving Certificate Applied Mathematics (Ordinary Level) 2012 by Gender.

The percentage of female candidates at this level (35·6%) is greater than at higher level (22·8%). It also represents a significant increase since 2007, the year of the previous report, when the percentage of female candidates at ordinary level was 12%.

Table 4 shows the percentage of candidates who obtained A grades, A+B+C grades, D grades and E+F+NG grades in 2009, 2010, 2011 and 2012.

Year	Number of Candidates	A	A+B+C	D	E+F+NG
2009	113	30·1	71·7	17·7	10·6
2010	116	34·5	80·2	6·9	12·9
2011	153	33·3	84·8	10·5	9·2
2012	146	37·8	81·0	12·3	6·7

Table 4: Summary of outcomes by grade Leaving Certificate Applied Mathematics (Ordinary Level) 2009 – 2012.

Analysis was conducted on the relative popularity of each question and on the performance of candidates in each question. Table 5 below ranks each question in two ways. Firstly, the questions are ranked according to candidate performance and secondly according to the question's popularity among candidates. Under the heading 'Performance', the average mark per question and corresponding rank order is given. Under the heading 'Popularity', the response rate per question and corresponding rank order is given. The topic for each question is also given.

It is clear that candidates favoured questions 1 to 6, as the response rate to questions 7, 8, and 9 is significantly lower than for the first six. As well as being unpopular, questions 7, 8, and 9 were also the lowest scoring questions.

Performance			**Popularity**		
Question	Average Mark (%)	Rank Order	Response Rate (%)	Rank Order	Topic of Question
1	89·2	1	97·9	1	Linear Motion
2	65·6	6	87·0	5	Relative Velocity
3	68·2	5	87·7	4	Projectiles
4	81·0	3	92·5	3	Connected Particles
5	86·2	2	94·5	2	Collisions
6	73·8	4	63·7	6	Centre of Gravity
7	59·8	8	21·9	8	Statics
8	60·6	7	25·3	7	Circular Motion
9	47·0	9	19·2	9	Hydrostatics

Table 5: Ranking of questions according to Average Mark and Response Rate[1]

[1] The statistical information in this report relating to the answering of the individual questions at Ordinary Level is based on the full batch of 146 scripts.

2.3 Analysis of Candidate Performance

Question 1 **Average Mark 89·2%** **Response Rate 97·9%**

This was the most popular and the best-answered question on the paper. The first two parts of the question were very well answered by almost all candidates. In calculating the distance from *P* to *Q* some candidates used a graphical approach but the majority used the method given in the marking scheme. Some candidates miscalculated the distances for the first two stages of the distance from *P* to *Q*. Part (iv) was the only part to present real problems with many candidates using an inappropriate equation or substituting incorrectly into $v^2 = u^2 + 2as$.

Common errors included:

- Taking speed at point *P* to be 0 rather than 8
- From the graphical approach taking the distance while accelerating as $\frac{1}{2}(12)(24) = 144$ rather than $\frac{1}{2}(12)(24) + 12(8) = 240$
- In part (iv) having $v^2 = 32^2 + 2(-4)(72)$ rather than $0^2 = u^2 + 2(-4)(72)$.

Question 2 **Average Mark 65·6%** **Response Rate 87·0%**

Some candidates had difficulty in correctly finding the velocity of A in terms of $\vec{i}$ and $\vec{j}$. Candidates had little difficulty in expressing the velocity B or the velocity of A relative to B in terms of $\vec{i}$ and $\vec{j}$. In part (iv) a number of candidates had difficulty in finding the shortest distance between A and B in the subsequent motion. In this part of the question candidates tended to get low or very high marks, i.e. there were very few mid-range answers.

Common errors included:

- $\vec{V}_{AB} = \vec{V}_A + \vec{V}_B$
- Ignoring the direction of the relative velocity $33 \cdot 69°$ and using the angle $45°$ instead and attempt to use the sine rule or Pythagoras to solve a triangle.
- Some candidates used velocities in place of distances in calculations.

Question 3 **Average Mark 68·2%** **Response Rate 87·7%**

This was a popular question and in general part (a) was well answered. Many candidates had difficulty in finding the initial velocity in terms of $\vec{i}$ and $\vec{j}$. Some candidates found the time to reach the greatest height but then failed to double this time to get the time taken to reach *Q*. Parts (b)(i) and (b)(ii) were generally well answered but part (b)(iii) caused difficulty for many candidates.

Common errors included:

- initial velocity $= 20\vec{i} + 20\vec{j}$ in part (a)
- speed at $A = \sqrt{21^2 + 50^2}$ rather than $\sqrt{21^2 + 20^2}$
- in part b(i) some candidates included an acceleration in the $\vec{i}$ direction.

Question 4 **Average Mark 81·0%** **Response Rate 92·5%**

This was a very popular question and the standard of answering was good.
Part (b) was well answered. Some candidates had difficulty in resolving the 12g force correctly.

Common errors included:

- Incorrect accelerations in the equations of motion
- Friction force applied to the 12 kg mass
- $12g - T = 12a$ rather than $12g\cos 60 - T = 12a$.

Question 5 **Average Mark 86·2%** **Response Rate 94·5%**

This was the second most popular and second best-answered question on the paper. Most candidates were able to find the speed of A and the speed of B after the collision. Despite the fact that kinetic energy is defined in the *Formulae and Tables* booklet, some candidates failed to use the correct formula for kinetic energy. Most candidates had little difficulty in finding the magnitude of the impulse imparted to A due to the collision.

Common errors included:

- $v_1 - v_2 = e(u_1 - u_2)$
- Kinetic energy = $\frac{1}{2}mv$
- Incorrect substitution for velocity when calculating the impulse.

Question 6 **Average Mark 73·8%** **Response Rate 63·7%**

This question was very often attempted as the candidate's sixth and final question. Part (a) of the question was very well answered. Most candidates were able to find the value of p and the value of q. A common error was to omit the combined weight of 19 N when calculating the centre of gravity of the system.

In part (b) of the question some candidates had difficulty in finding the co-ordinates of the centre of gravity of the triangular lamina.

A common error was

- $(231 \cdot 43)(x) = 486(12) + 254 \cdot 57(9)$ rather than
  $(231 \cdot 43)(x) = 486(12) - 254 \cdot 57(9)$.

Question 7 **Average Mark 59·8%** **Response Rate 21·9%**

This question was not very popular and it was in many instances poorly answered. In part (i) most candidates were able to transfer the information given in the question to a clearly labelled diagram. However in part (ii) some candidates had difficulty in writing down the equations that arose from resolving the forces horizontally and vertically. Parts (iii), (iv) and (v) were either badly answered or very well answered. The inability to take moments about a suitable point was the main reason for many candidates being unable to finish these parts of the question.

Common errors included:

- Resolving T incorrectly
- Incorrect distance value when taking moments.

Question 8 **Average Mark 60·6%** **Response Rate 25·3%**

Part (a) was the best-answered part of the question. Most candidates were able to find the angular velocity and the centripetal force acting on the particle. In part (b) a number of candidates did not get a correct value for the radius of the horizontal circle. Many candidates had difficulty in identifying the correct reaction force and then resolving it horizontally and vertically.
Common errors included:

- $R = g\cos\alpha$ and $R = mr\omega^2 \sin\alpha$
- $R = mr\omega^2$
- $R = g$
- using an inconsistent set of units.

Question 9 **Average Mark 47·0%** **Response Rate 19·2%**

This question was the least popular question on the paper and it was generally poorly answered. While 28% of the candidates who attempted the question received a mark of 40 or more, 56% received a mark of 10 or less. There were many reasonable attempts at part (a) of the question with candidates able to find the volume of the metal but many candidates had difficulty in finding the relative density of the metal.

Common errors included:

- Weight of piece of metal $= \rho V$ rather than ρVg
- $B = W$ i.e. buoyancy force = weight of object.

A minority of candidates made a reasonable effort at Part (b) of the question. Candidates had $T + B = W$ but were unable to find the buoyancy force or the weight of the cylinder and hence the tension in the string.

Common errors included:

- incorrect units
- $W = T - B$.

2.4 Conclusions

- The overall standard of answering was very good, particularly in questions 1, 4, 5 and 6, and it was similar to previous years' standards.

- This year there was a small increase in the number of candidates attempting the questions on Centre of Gravity and Hydrostatics. As in previous years, the questions on Statics and Hydrostatics were the least popular questions on the paper.

- Candidates showed their usual strength in questions on linear motion, connected particles and collisions.

- Some candidates had difficulty in resolving vectors into components in questions 2, 4, 7 and 8.

- Mathematical errors were infrequent and misreading of questions was rare.

- Candidates appeared to understand each question and there was little or no confusion as to what was required.

2.5 Recommendations to Teachers and Students

- Complete coverage of the syllabus is recommended. Confining syllabus coverage to 6 or 7 topics limits choice and may also present difficulties if parts of different topics are examined in the same question.

- Candidates are advised to manage their time and attempt six questions.

- Candidates should take care to transfer accurately the information given in the question – many marks are lost through poor substitution.

- Candidates should be encouraged to start each question at the top of a left hand page as slips in transferring information to the top of a new left hand page are common.

- Use of the correct form of an equation should be practised. This was particularly significant in the Kinetic Energy calculation where many students omitted the square from the original equation or failed to square the value in the calculation.

- Candidates should ensure that they are fully aware of the information in the *Formulae and Tables* booklet and make appropriate use of it.

- Candidates are advised to practise force diagrams and to pay attention to the question of whether friction does or does not apply. This is particularly important as in most cases equations must be formed using the forces in the diagram and the direction or sense of the force is significant.

3. Higher Level

3.1 Introduction

The examination consists of one paper, comprising ten questions. Six questions must be answered correctly to obtain full marks. Each question carries 50 marks. The duration of the examination is two hours thirty minutes.

The number of candidates taking higher level Applied Mathematics in the Leaving Certificate examination increased by 5·5% this year. Table 1 shows that a very high proportion of candidates take the higher level option. The total number of candidates taking the higher level paper in 2012 was 1344. This compares with 1213 in 2010 and 1274 in 2011.

Year	Total number of candidates taking Applied Mathematics	Number of higher level candidates	Percentage of total Applied Mathematics cohort	Percentage of total Leaving Certificate cohort
2008	1395	1288	92·3	2·44
2009	1446	1333	92·2	2·46
2010	1329	1213	91·3	2·22
2011	1427	1274	89·3	2·34
2012	1490	1344	90·2	2·56

Table 1: Number of Leaving Certificate candidates taking Applied Mathematics (Higher Level) 2008 – 2012

3.1 Performance of Candidates

Table 2 shows how the candidates performed with a summary of the results of the examination for 2009, 2010, 2011, 2012.

Year	Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG	Total
2009	Number	182	134	136	150	120	125	105	89	95	62	55	55	18	7	1333
	%	13·7	10·1	10·2	11·3	9·0	9·4	7·9	6·7	7·1	4·7	4·1	4·1	1·4	0·5	
2010	Number	256	103	111	108	87	96	63	94	48	57	95	60	29	8	1213
	%	21·4	8·3	9·2	8·8	7·2	7·8	5·2	7·7	4·0	4·7	7·8	4·9	2·4	0·7	
2011	Number	190	154	118	144	118	116	79	79	87	46	65	57	18	3	1274
	%	15·2	11·8	9·3	11·4	9·3	9·0	6·2	6·2	6·8	3·6	5·1	4·5	1·4	0·2	
2012	Number	248	126	127	143	125	80	92	104	61	60	68	69	30	11	1344
	%	18·5	9·4	9·4	10·6	9·3	6·0	6·8	7·7	4·5	4·5	5·1	5·1	2·2	0·8	

Table 2: Summary of outcomes for leaving Certificate Applied Mathematics (Higher Level) 2009−2012.

Table 3 below shows the breakdown of the 2012 results in Higher Level Applied Mathematics by gender.

Grade	A1	A2	B1	B2	B3	C1	C2	C3	D1	D2	D3	E	F	NG	Total
Number	248	126	127	143	125	80	92	104	61	60	68	69	30	11	1344
Total %	18·5	9·4	9·4	10·6	9·3	6·0	6·8	7·7	4·5	4·5	5·1	5·1	2·2	0·8	
No. Female	28	33	29	36	38	22	22	30	12	12	18	18	7	2	307
% Female	9·1	10·7	9·4	11·7	12·4	7·2	7·2	9·8	3·9	3·9	5·9	5·9	2·3	0·7	
No. Male	220	93	98	107	87	58	70	74	49	48	50	51	23	9	1037
% Male	21·2	9	9·5	10·3	8·4	5·6	6·8	7·1	4·7	4·6	4·8	4·9	2·2	0·9	

Table 3: Grade outcomes Leaving Certificate Applied Mathematics (Higher Level) 2012 by Gender.

The proportion of female candidates, at 22·8%, is similar to the proportion in 2007, the year of the previous report, when it was 24·3%.

Table 4 shows the percentage of candidates who obtained A grades, A+B+C grades, D grades and E+F+NG grades in 2009, 2010, 2011 and 2012.

Year	Number of Candidates	A	A+B+C	D	E+F+NG
2009	1333	23·8	78·3	15·9	6·0
2010	1213	29·7	75·6	16·5	8·0
2011	1274	27·0	78·4	15·5	6·1
2012	1344	27·9	77·7	14·1	8·1

Table 4: Summary of outcomes by grade Leaving Certificate Applied Mathematics (Higher Level) 2009 – 2012.

Analysis was conducted on the relative popularity of each question and on the performance of candidates in each question. Table 5 below ranks each question in two ways. Firstly, the questions are ranked according to candidate performance and secondly according to the question's popularity among candidates. Under the heading 'Performance' the average mark per question and corresponding rank order is given. Under the heading 'Popularity' the response rate per question and corresponding rank order is given. The topic for each question is also given.

It is clear that candidates favoured questions 1 to 6 along with question 10, as the response rate to questions 6, 7, 8, and 9 is significantly lower than for the first six. As well as being unpopular, questions 6, 7, and 8 were also the lowest scoring questions.

Performance			Popularity		
Question	Average Mark (%)	Rank Order	Response Rate (%)	Rank Order	Topic of Question
1	75·0	2	95·1	1	Linear Motion
2	66·5	6	68·6	6	Relative Velocity
3	73·6	4	92·0	4	Projectiles
4	74·3	3	94·2	2	Connected Particles
5	75·1	1	92·4	3	Collisions
6	61·9	8	22·2	8	Circular Motion & SHM
7	35·4	10	12·2	9	Statics
8	61·2	9	27·3	7	Rigid Body Motion
9	70·0	5	9·9	10	Hydrostatics
10	65·3	7	79·0	5	Differential Equations

Table 5: Ranking of questions according to Average Mark and Response Rate[2]

[2] The statistical information in this report relating to the answering of the individual questions at Higher Level is based on a large sample of the total number of candidates.

3.3 Analysis of Candidate Performance

Question 1 **Average Mark 75·0%** **Response Rate 95·1%**

This was a popular and well-answered question. In general part (a) was very well answered with most candidates getting full marks for this part. The most common error was mixing up the times, putting $t+2$ or $t-2$ in for the incorrect particle. Another common error was equating $v_1 = v_2$ to find when the particles met.

Part (b) (i) of the question was well answered by those candidates who took an algebraic approach to the solution as in the marking scheme. Very few candidates successfully used a graphical approach to solve part (i) of the problem. Part (b) (ii) was poorly answered, although there were some nice solutions to this part, including an approach using relative velocity for the last 8 seconds.

Question 2 **Average Mark 66·5%** **Response Rate 68·6%**

As in 2010 and 2011, this was the sixth most popular question. Part (a) was well answered. Candidates had little difficulty in calculating the velocity of the rain relative to the car but had difficulty in finding the angle at which the rain appeared to strike the windscreen. A small number of candidates took the $\vec{i}$ and $\vec{j}$ directions along and perpendicular to the windscreen and found the required angle with little difficulty.

Common errors included:

- $\vec{V}_r = 25\cos 20\,\vec{i} \pm 25\sin 20\,\vec{j}$
- $\vec{V}_c = 20\cos 32\,\vec{i} \pm 20\sin 32\,\vec{j}$
- failed to add $32°$ to $50.55°$ to get the required angle.

Part (b) of the question was in general well answered. Most candidates had no difficulty in finding the magnitude and direction of the velocity of B relative to A.

A common error was $\vec{V}_{BA} = \pm 41\,\vec{i} \pm 24\,\vec{j}$.

The candidates who answered parts (ii) and (iii) using the method in the marking scheme were more successful than those candidates who tried to solve the triangles using the sine and cosine rules.

A common error was that the ships can begin to exchange signals after $\frac{20}{25} = 0\cdot 8$ hours.

Question 3 **Average Mark 73·6%** **Response Rate 92·0%**

This was a popular question. In general part (a) (i) was well answered but a surprising number of candidates failed to solve for two values of α.

Common errors included:

- $2\alpha = \sin^{-1} 0 \cdot 96 \Rightarrow 2\alpha = 73 \cdot 74 \Rightarrow \alpha = 36 \cdot 87$ and $\alpha = 180 - 36 \cdot 87$
- $2\alpha = \sin^{-1} 0 \cdot 96 \Rightarrow 2\alpha = 73 \cdot 74 \Rightarrow \alpha = 36 \cdot 87$ i.e. just one value for α.

Part (a) (ii) was very well answered although some candidates omitted this part of the question even after finding the two correct values of α in the previous part of the question.

Part (b) was generally well answered. Most candidates progressed to $\sin\alpha = 2\sqrt{3}\cos^2\alpha$ or an equivalent equation in α and then had difficulty in solving the equation, having spent some time exploring different methods of finding α.

Common errors included:

- $r_j = 20\sin(\alpha - 90) \times t - \frac{1}{2} g \cos\alpha \times t^2$
- $r_j = 20\sin(90 - \alpha) \times t - \frac{1}{2} g \cos\alpha \times t^2$
- rebound velocity $= e\sqrt{\left(40\sqrt{3}\right)^2 + 20^2}$
- rebound velocity $= \sqrt{\left(e \times 40\sqrt{3}\right)^2 + 20^2}$ rather than $\sqrt{\left(40\sqrt{3}\right)^2 + (e \times 20)^2}$.

Question 4 **Average Mark 74·3%** **Response Rate 94·2%**

This was a popular question and it was well answered. Part (a) was very well answered. Most candidates were able to write out the equations of motion and find the common acceleration of the particles and hence the speed with which B hit the ground. The majority of candidates answered part (ii) as per the marking scheme but some candidates had an incorrect acceleration for this section of the motion.

Common errors included:

- $mg - \frac{11mg}{13} = mf$ rather than $mg - \frac{11mg}{13} = 2mf$
- taking the acceleration in part (ii) as $-\frac{5g}{13}$ or $-\frac{g}{13}$ instead of $-\frac{11g}{13}$.

Part (b) was well answered by most candidates although very few candidates got full marks for this part of the question. Many candidates were able to write down the equations of motion and find the tension in the string. Very few candidates answered part (b) (ii) correctly.

A common error was having incorrect accelerations either through assuming that the two particles and the pulley all had the same acceleration, or otherwise failing to establish the correct relationship between the accelerations of these three things.

Question 5 **Average Mark 75·1%** **Response Rate 92·4%**

Part (a) was in general very well answered. Most candidates found, in terms of *e*, the speed of A and B after the first collision and correctly applied the laws governing the collision between B and C. However many candidates had difficulty showing the condition for which there were no further collisions. Many candidates tried to show $v_1 < v_3 < v_4$ numerically with few solving $e^2 - 3e + 1 < 0$ algebraically.

Common errors included:

- when applying Newton's Experimental Law of Restitution for the second collision had $v_3 - v_4 = -e(6 + 6e)$ rather than $v_3 - v_4 = -e(3 + 3e)$
- substituting $e = \dfrac{3 - \sqrt{5}}{2}$ to find the speed of each sphere after the second collision.

Those who attempted part (*b*) of this question along the lines of the marking scheme and found $v_1 = \frac{1}{3}u\cos\alpha$ usually completed this part of the question correctly. However those who started with $u\cos\alpha = v\cos(\theta + \alpha)$ and $u\sin\alpha = v\sin(\theta + \alpha)$ and then expanded $\cos(\theta + \alpha)$ and/or $\sin(\theta + \alpha)$ generally had difficulty in solving the question correctly.

Common errors included:

- incorrect component for the velocity of P along the line of centres before impact
- unable to find a correct expression for $\tan(\theta + \alpha)$.

Question 6 **Average Mark 61·9%** **Response Rate 22·2%**

Part (a) of the question was generally well answered. Most candidates were able to find the maximum acceleration of the particle. However many candidates failed to take the weight of the particle into account when forming the equation of motion in part (a) (ii).

Part (b) (i) was very well answered. Most candidates were able to find the speed of the particle at B. Where errors did occur they tended to be when working out the height for the potential energy of the particle when it left the sphere. Most candidates had difficulty in finding the value of *k* in part (ii).

Question 7 **Average Mark 35·4%** **Response Rate 12·2%**

This was one of the least popular questions and it was the question that caused most difficulty for candidates. Quite a number of candidates found part (a) difficult and were unable to find the value of h.

Common errors included:

- $|AB| = x$ and $|BC| = hx$ rather than $|BC| = \frac{x}{h}$
- weight of $|AB| = W$ and weight of $|BC| = hW$ rather than weight of $|BC| = \frac{W}{h}$.

Part (b) caused difficulty for most candidates. The horizontal and vertical equations were usually found correctly but very few candidates were able to correctly take moments about a suitable point. Many candidates did not utilise the symmetrical aspect of the question, making taking moments more complicated.

Question 8 **Average Mark 61·2%** **Response Rate 27·3%**

In general, part (a) was very well answered and, as in other years, a small number of candidates began by answering part (a) correctly but failed to attempt part (b) of the question.

Very few candidates got full marks for part (b). Many candidates had difficulty in finding an expression for the tension in the string in terms of I, m and r. The candidates who correctly found an expression for the acceleration then usually found the mass of the pulley in terms of m. The most common source of error was failing to find a relationship between the distance h and the corresponding speed v.

Question 9 **Average Mark 70·0%** **Response Rate 9·9%**

This was the least popular question on the paper but it was much better answered than in previous years. This year it was the fifth best-answered question on the paper. Part (a) was very well answered and most candidates were able to obtain full marks.

Part (b) was well answered. Some candidates split the weight of the rod into two parts, 'wet part' and 'dry part' and as a result complicated their calculation when taking moments about a suitable point. In general, those who had taken moments correctly solved the problem completely.

A common error was in calculating the buoyancy force or in working out the moments for the buoyancy force.

Question 10 **Average Mark 65·3%** **Response Rate 79·0%**

Part (a) was reasonably well answered. The majority of candidates separated the variables and integrated correctly. The main source of error was the use of incorrect limits. A small number of candidates attempted to answer the question without using integration.

Common errors included:

- incorrect limits – 80 and 60 instead of 60 and 40
- error in the rules of logs
- $k = \frac{1}{10}\ln(1 \cdot 5)$ rather than $k = 0 \cdot 0405$
- $\theta = 21 \cdot 8°$ rather than $\theta = 21 \cdot 8 + 20 = 41 \cdot 8°$

Part (b) (i) was generally very well answered.

Common errors included:

- $\frac{dv}{dt} = +kv^2$
- $\int \frac{1}{v^2}\ dv = \ln(v^2)$ or $2\ln v$

Part (b) (ii) was well answered by most candidates. A number of candidates initially tried to use the given integral but in general realised that $v\frac{dv}{dx} = -kv^2$ was a more direct method. A small number of candidates attempted this question using the equations of linear motion for constant acceleration.

3.4 Conclusions

- The overall standard of answering was quite good, particularly in questions 1, 3, 4, 5 and 9(a), and it was similar to previous years' standards.

- Very few candidates attempted the questions on Statics, Circular Motion, Simple Harmonic Motion and Hydrostatics.

- Candidates showed their usual strength in methodology and in algebra.

- Some candidates had difficulty in solving trigonometric equations, as in questions 3(a) and 3(b), and manipulating inequalities, as in question 5(a).

- Candidates appeared to understand each question and there was little or no confusion as to what was required.

3.5 Recommendations to Teachers and Students

- Complete coverage of the syllabus is recommended. Confining syllabus coverage to 6 or 7 topics limits choice and may also present difficulties if parts of different topics are examined in the same question.

- Candidates are advised to manage their time and attempt six questions.

- Candidates should be encouraged to start each question at the top of a left hand page as slips in transferring information to the top of a new left hand page are common.

- Candidates should read each question carefully, paying particular attention to special requirements such as the units of quantities given or required.

- Candidates should ensure that they are fully aware of the information in the *Formulae and Tables* booklet and make appropriate use of it.