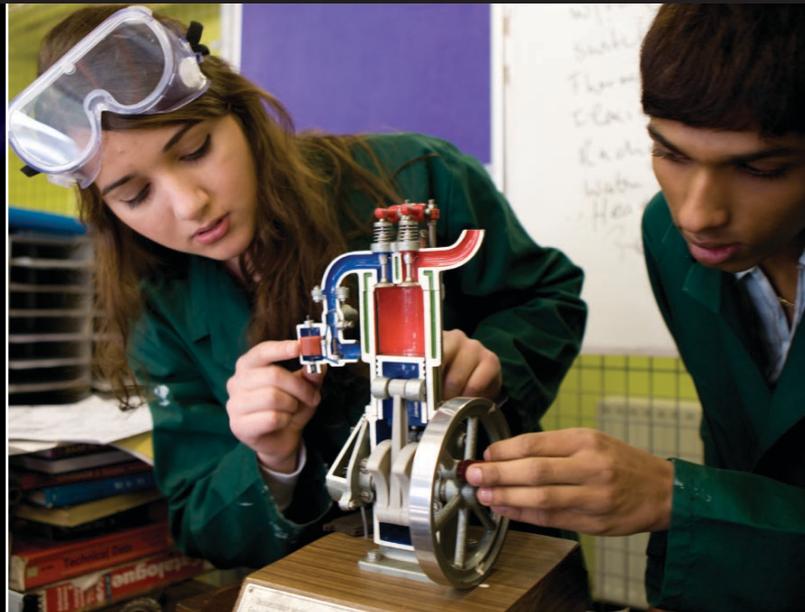
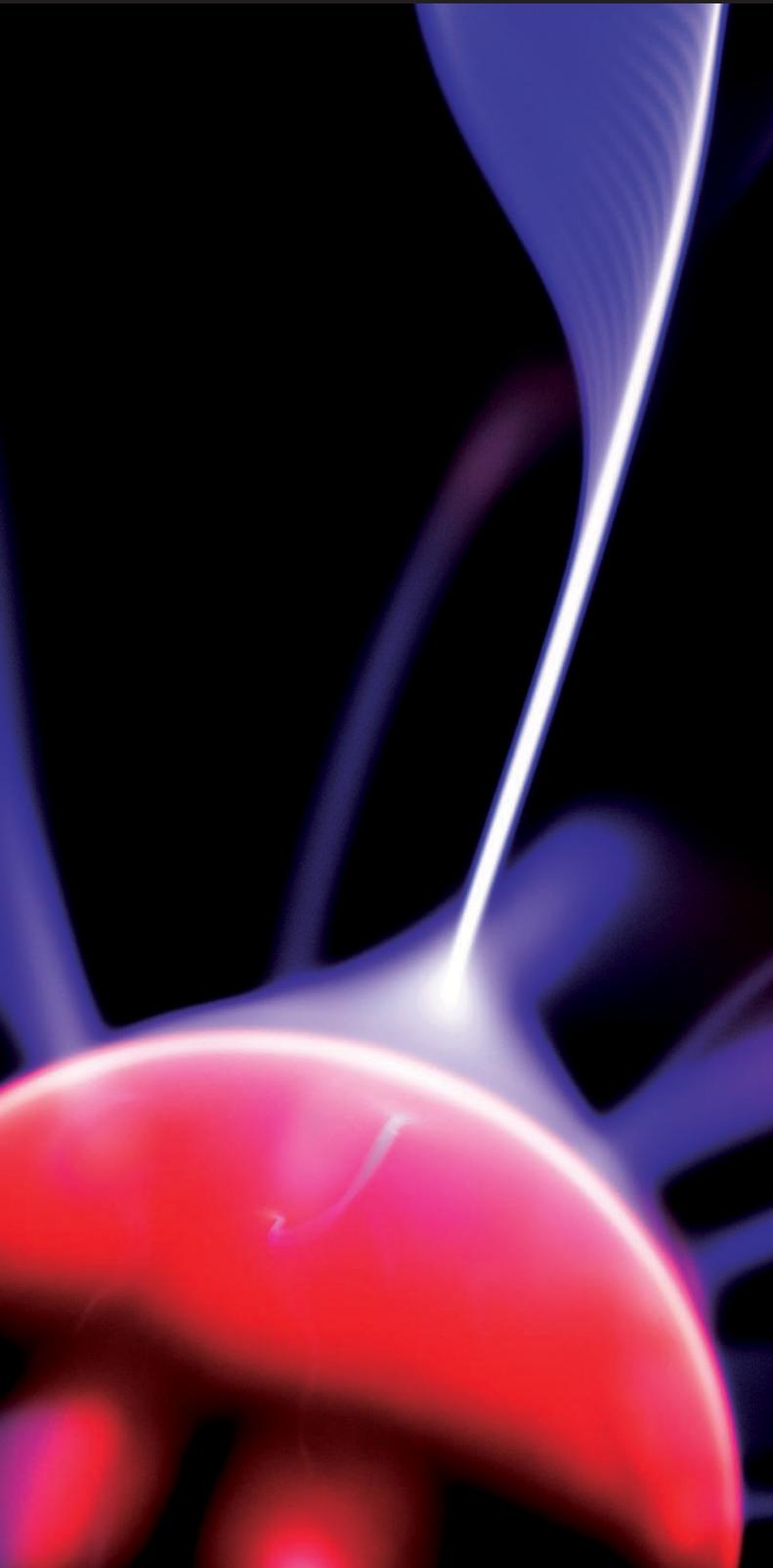


# Physics in Scotland: the brightest minds go further

November 2009

A report prepared for the Institute of Physics by Michael Hatcher



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# Executive summary

Physics training equips students with a wide range of skills and knowledge and physics graduates are employed in all sectors of the Scottish economy. This report describes the results of a survey of graduates from Scottish university physics departments, showcasing the excellent career prospects for those who study the subject, and highlighting the wealth and prosperity they contribute.

Key findings:

- Physics graduates find employment in a wide range of industry sectors, with a significant proportion relocating overseas.
- Physics graduates earn above the median UK wage and succeed in management positions and consultancy roles.
- More than half of first-degree physics graduates earn a salary in excess of £40 000 and more than half with a PhD in physics earn in excess of £50 000.
- The financial rewards for the best physics graduates on offer outside of the teaching sector are far in excess of those within teaching.
- Female physics graduates on average earn less than their male counterparts and fewer of them reach the best-paid positions.



# 1: Impact

## Heritage

In Scotland, physics enjoys a particularly strong heritage. Names such as James Clerk Maxwell, Alexander Graham Bell and James Watt resonate powerfully in both the history classroom and the physics laboratory, their scientific and technological endeavour still relevant in the 21st century.

The impact of these pioneering minds can be felt around the world, and high-technology industries, such as the optical communications networks that carry internet traffic globally, still owe much to the likes of Maxwell.

Scottish physicists remain highly influential. Peter Higgs, emeritus professor at the University of Edinburgh, first predicted the existence of the eponymous boson. Confirmation of the existence of the Higgs boson, which is the primary aim of those working on the high-profile Large Hadron Collider at CERN, would usher in a new era of fundamental physics.

## Economic impact

More pertinent for policymakers looking to shape the future of Scotland is the influence of physics and physicists on the Scottish economy. In terms of their contribution to the local economy, physicists punch well above their weight.

In 2007 the Institute of Physics report *Physics and the Scottish Economy*<sup>1</sup> found that more than 100 000 Scottish jobs relied on industries where the use of physics-based technologies was rated as critical. These jobs represented 4.3% of Scotland's workforce and contributed £8 bn to the country's economy, equivalent to 9.4% of the total Scottish gross value added (GVA).<sup>2</sup>

One of the key reasons for this economic contribution is the close relationship between engineering and physics. According to figures from the Royal Academy for Engineering, 35% of current engineering research chairs and 16% of engineering research fellows have a first degree in physics. As noted in the 2008 *RCUK Review (Wakeham Review) of UK Physics*,<sup>3</sup> physicists are ubiquitous and can be found in medicine and biological sciences as well as engineering.

The implications are clear: the physics-based industrial sector has a major beneficial impact on the wider economy, and physics graduates can make substantial contributions to many industries. An additional benefit is that physics graduates are among the best paid in the country, supporting local economies through their spending.

Clearly, the continued health of the Scottish economy will be linked to a sustainable supply of physics graduates who are able to contribute to the range of industries requiring their expertise.

The results of the survey of graduates from Scottish physics departments demonstrate that the outlook for current and future physics graduates is a good one. Studying physics opens up a wide range of career options, the possibility of an excellent salary and opportunities to move between sectors in senior management positions within and beyond UK shores.

The survey also shows that policymakers in the country must now address some key failings that threaten to jeopardise the long-term sustainability of the Scottish economy. Notably, they need to continue attracting and supporting specialist physics teachers to nurture those following in the footsteps of Maxwell, Bell and Watt.

## Survey respondents

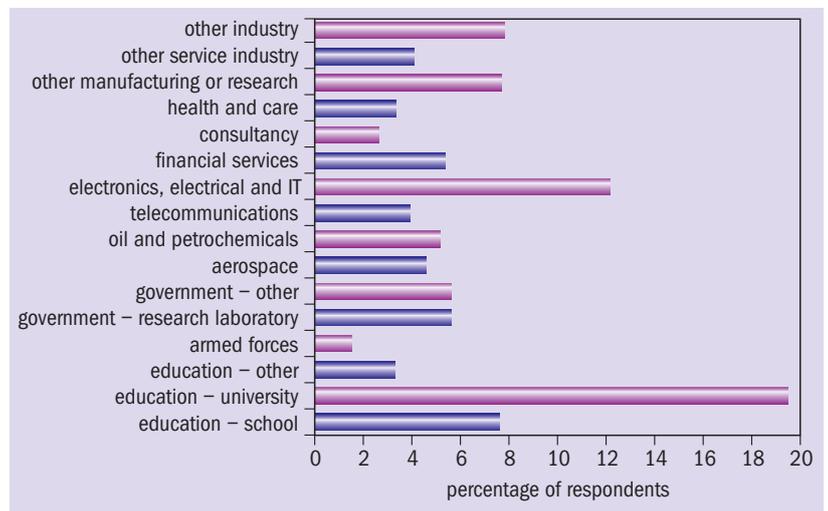
The survey responses from physics graduates from Scottish universities comprised a broad spread of ages. Just over half of the respondents had so far attained a Bachelors degree only, with a further 35% of first-degree physics graduates moving immediately to postgraduate study. More than one in five of the respondents had achieved both a Bachelors and a PhD qualification.

Respondents were evenly distributed across the major Scottish institutions, with the largest proportions graduating from the universities of St Andrews and Edinburgh; the breakdown is broadly in line with current physics undergraduate distribution.

## Physicist employment

Higher education is the leading employment destination for physics graduates, however, a striking finding is the wide range of sectors that employ significant numbers of physics graduates, highlighting the versatility of the subject (figure 1).

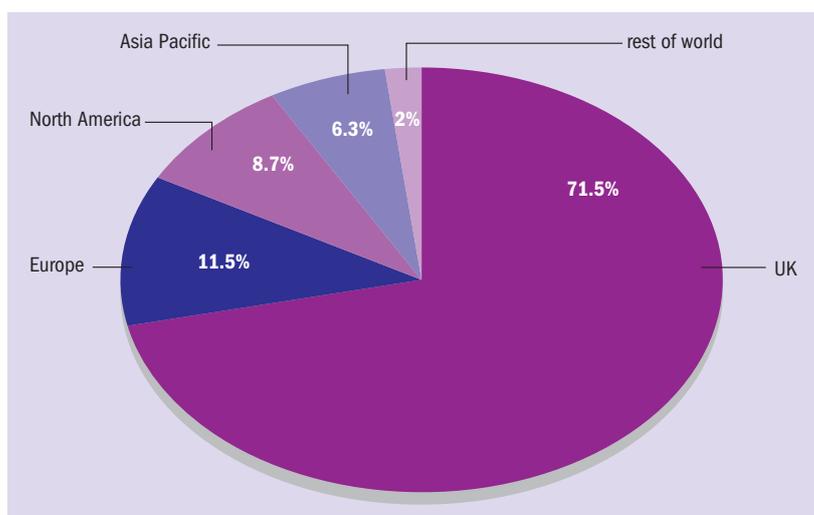
The electronics, electrical and information technology



**Figure 1: Sector for initial employment of physics graduates from Scottish institutions.** While further university work stands out as the most likely option, the skills of physicists are valuable in a wide range of industries.

**Table 1: Leading employment sectors for new physics graduates 1966–2009.**

	pre-1966	1966–1970	1971–1975	1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006 onwards
<b>Sector #1</b>	education – school	other industry	education – university	electronics/ IT/software	education – university	education – university				
<b>Sector #2</b>	government research laboratory	education – university	education – school	electronics/ IT/software	electronics/ IT/software	electronics/ IT/software	electronics/ IT/software	education – university	financial services	financial services
<b>Sector #3</b>	education – university	education – school	electronics/ IT/software	other industry	oil industry	financial services	other industry	other industry	education – school	health and care services



**Figure 2: Location of current employment.** Going global: physics graduates from Scottish universities work throughout the world.

(IT) sector accounted for the second-largest segment of physics graduates currently working in Scotland, ahead of significant numbers in other economically valuable areas such as telecommunications, oil and petrochemicals, and financial services. Slightly less popular among physics graduates, though still significant employers, are aerospace, healthcare and consultancy.

The rise and fall in the importance of different industries to the Scottish economy over the years can be seen in the survey responses. The initial employment of physics graduates (table 1) has changed markedly over the course of the past half-century, though further university employment ranks consistently near the top of the list. Prior to 1985, physics graduates would often move into government research laboratories on departing university. However, the decline of government laboratories as a key choice for new physics graduates over the past few decades has seen various industries replace that role.

The decade from 1976 to 1985 saw the emergence of the local oil industry and it became the third most popular option for new physics graduates in the early 1980s. After the oil boom, opportunities in electronics and IT appeared, peaking in the technology boom of the late-1990s, when this sector – supported to a great extent by the emergence of “Silicon Glen” – was the leading destination for emerging physicists. Since 2001, finan-

cial services has been the second most popular starting point for physics graduates, only ranking behind further university study.

In the wake of the current decline in financial services, it remains to be seen which sector the future cohorts of graduate physicists will gravitate towards. Among the engineering sectors, it is possible that the energy industry will offer the greatest potential in future decades.

Whatever happens, the message is that a physics degree equips graduates with a skill set that can be applied in a wide range of strategically and economically important industries

### High earnings and career mobility

Two results that stand out from the survey are the potential for high earnings and the extensive international deployment of physics graduates (figure 2). Although the majority (71.5%) of respondents were resident in the UK at the time of the survey, a significant minority were distributed around the world, with 11.5% in mainland Europe, 8.7% employed in North America and 6.3% based in the Asia-Pacific region.

Again, the message is clear: physicists can enter employment in a range of global industries, and graduating in physics offers the potential for an overseas move. The finding raises another important point: if the UK or Scotland is unable to offer sufficient opportunities for these talented physicists, then those talents and their high-paid jobs could easily be lost to rival economies.

Of the respondents, more than half disclosed an annual salary in excess of £40 000 and 40% claimed to be earning more than £50 000 (figure 3). This compares with a median annual salary in the UK of just under £25 000.<sup>4</sup>

The high earning potential of physicists highlights another key finding: contrary to media stereotypes, large numbers of physicists possess the transferable, “soft” skills required in the modern economy. More than one-fifth of those surveyed said that they work in a management position, with a further 10% in consultancy roles and a small minority in technical support, marketing and retail positions.

With 26% of those surveyed working in technical research and development roles, the results of the

**Table 2:** Current declared industry of employment stated by survey respondents, in order of prevalence, according to last university attended.

Aberdeen	Dundee	Edinburgh	Heriot-Watt	St Andrews	Strathclyde
education – university	electronics/IT/software	education – university	education – university	education – university	electronics/IT/software
oil industry	education – university	financial services	electronics/IT/software	electronics/IT/software	education – university
education	telecommunications	oil industry	other industry	other industry	other industry
health and care services	other industry	electronics/IT/software	telecommunications	financial services	aerospace
education – school	other service industry	other industry	consultancy	consultancy	oil industry
consultancy (science/technical)	consultancy (management)	other service industry	(science/technical)	(science/technical)	
		education – school			

survey suggest that many physicists enter employment with a focus on the “hard” technical skills learned in the laboratory, before going on to exploit their transferable skills in more lucrative management and consultancy positions across a range of industries.

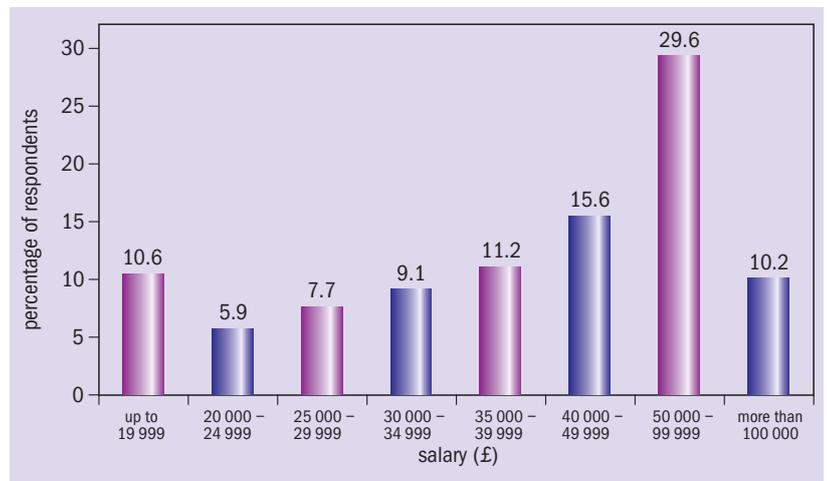
### Financial benefits of further study

The salary data also highlight the beneficial impact of higher qualifications. Half of the physics graduates surveyed who went on to study for a PhD claimed a current salary in excess of £50 000.

A key finding in the recent Price Waterhouse Coopers’ report on the economic benefits of UK physics and chemistry graduates<sup>5</sup> found that, while scientists tend to earn more than other graduates, the trend becomes much more apparent after the age of 30. The results from this survey agree with this earlier finding, with half of those graduating in physics from Scottish institutions prior to 1991 now claiming to earn a salary in excess of £50 000. Clearly, an investment in science learning can bring a rewarding financial pay-off for both the individual and the state.

The impact is most notable for those physics graduates who go on to exploit their soft skills in management roles. According to the survey, some three-quarters of those in management positions are now earning more than £50 000 and 28% of that group say that they earn more than £100 000, perhaps highlighting the recent influence of the lucrative financial services sector and its importance to Scotland.

Though of course welcome for the individuals and the public purse, this earnings potential is a double-edged sword as far as physics teaching is concerned. With such riches on offer in rival sectors, is it any wonder that many of the most talented physicists will ignore



**Figure 3: Current annual salary claimed by physics graduates from Scottish institutions.** More than half of the physicists surveyed said that they earned more than £40 000 per year.

the attractions of returning to the classroom as a long-term vocation?

### Regional variations

Unsurprisingly, some subtleties in the survey responses highlight the importance of different industries in different parts of Scotland (table 2). For graduates from the University of Aberdeen, the oil industry ranks highly, as does the financial services sector for Edinburgh alumni. For the rest of Scotland’s physics departments – Dundee, Heriot-Watt, St Andrews and Strathclyde – it is the electronics and IT sector that dominates.

The survey also revealed slight variations in earning potential related to which university graduates had attended. Strathclyde was most likely to produce high earners, followed by Edinburgh, Heriot-Watt and Aberdeen – the latter possibly a reflection of the local oil industry.

## 2: Sustainability

### Teaching and careers advice

The survey shows that a physics graduate from a Scottish university, particularly one who goes on to study for a doctorate, can expect above-average earnings, a flexible career path and opportunities for overseas employment. Though welcome, these findings highlight one of a number of challenges that policymakers must overcome to sustain the important economic contribution that physics graduates make. That is, the appointment and retention of high-quality, specialist physics teachers.

According to a 2006 study by the National Foundation for Educational Research,<sup>6</sup> only 19% of school science teachers in the UK were trained in physics, while a quarter of secondary schools have no teachers at all who specialise in physics. However, the situation in Scotland is rather different because, except for a handful of rural schools, there is at least one specialist physics teacher in every secondary school. There is also a stronger focus on continued professional development for teachers and vacancy levels for physics teachers in the country are at historic lows.<sup>7,8</sup>

Given the rewards on offer to talented physics graduates in sectors of the economy outside of education and research, there is a need to maintain this support to ensure that graduate physicists are attracted to teaching in sufficient numbers.

Otherwise, the impact on younger students deciding which subjects to follow at the Scottish Higher level and beyond will be a predictable one: fewer students would be likely to select physics without positive experience from teachers who are specialists in that field.

Students at this level may have little awareness of the lucrative and flexible careers that a physics degree can lead to, and careers professionals should ensure that careers advice to students considering further study of physics is up to date and accurate in this regard.

### Gender disparity

Another finding from the survey is the apparent disparity in earnings between male and female physics graduates, although this is partly explained by the larger proportion of male graduates among the more experienced respondents. While more than half of the female physics graduates surveyed earned less than £35 000 per year, this was only true of 29% of the male respondents.

Specific results include the findings that only 11% of those respondents in management positions were female and only 6% of consultants (19% of total survey respondents were female).

The precise reasons for these results demand further investigation, although, as noted in the Wakeham Review, the fact that women are more likely than men to enter the lower-paid teaching profession will have some impact. It is possible that simply creating greater awareness among female students of the significant earnings potential and career opportunities that a physics degree could provide them with may help to redress this balance, although this may in turn have a negative impact on the supply of specialist physics teachers.

### The graduate pipeline

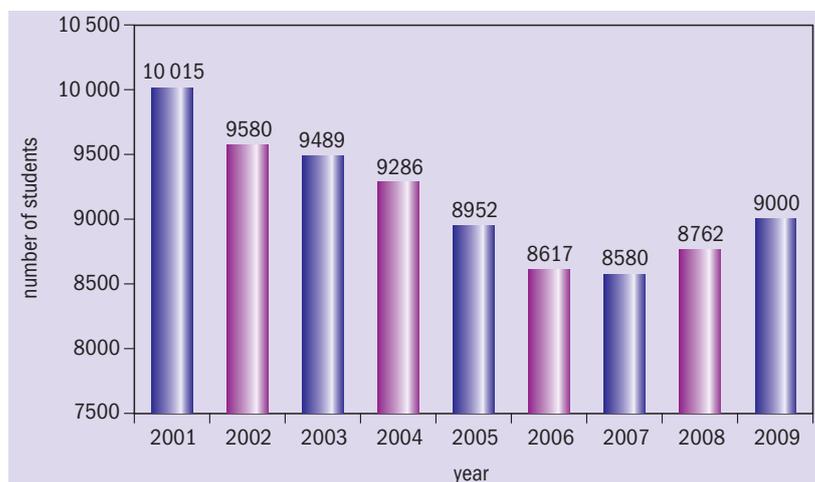
Perhaps of wider concern is the declining number of physics students, of both genders, in the education “pipeline”. Between 2001 and 2007, the number of students taking physics at the Scottish Higher level decreased by nearly 15% (figure 4).

In the past couple of years, the number of students taking the physics Higher has increased, though only marginally, reaching just over 9000 in 2009.<sup>9</sup> While this marks a welcome upturn, reversing a downward trend seen for a decade or more, the current level remains historically low, and is still 10% below the 10 015 physics students taking Higher physics as recently as 2001.

The concern is that the pipeline of physics graduates will also, in turn, decline, although the Wakeham Review did find that the number of physics undergraduates in the UK as a whole had held up well over the past decade, despite lower numbers of A-level and Higher physics entrants. The long-term implications for the Scottish economy of a decline in the number of physics graduates, both in terms of a skills shortage and the reduced contribution to the state and to local economies, are yet to be felt.

The employment of talented physicists has historically been driven by the emergence of key, high-technology industrial and commercial sectors: from electronics and communications, through oil and petrochemicals, to financial services. For Scotland to attract and retain the physicists of the future, there needs to be a strong

**Figure 4: Scottish Higher students 2001–2009.** The number of students taking the Scottish Higher physics course has steadily decreased during the past decade and, despite a slight upturn more recently, numbers remain significantly lower than the historical average.<sup>9</sup>



domestic source of high-earning opportunities.

Looking forward, it appears unlikely that the number of opportunities in the financial services sector will remain at the level seen in recent years, so to which industries will Scotland's most talented physics graduates now look for lucrative employment? The local oil industry may also be expected to shrink, along with the North Sea reserves, while the electronics industry, although benefiting from "Silicon Glen" and more than 1000 companies involved in the electronics sector in Scotland, remains fragile in the current recession.

There is, perhaps, an opportunity for Scotland to create for physicists the types of roles that will prove to be an investment in its economic future. In earlier decades, it was government research laboratories that nur-

tured the expertise and provided the legacy that is still driving Scotland's economy today. A similar investment now, to attract and retain physics graduates, could be made across the energy, engineering and education sectors – all of which would stand to benefit from physics knowledge.

Given Scotland's natural resources and the political push to restrict carbon-dioxide emissions, the renewable-energy sector certainly ought to present many opportunities for physicists. Installations such as grid-connected wind farms, as well as future energy generation through wave or tidal power, and efficiency improvements to electrical grid transmission, will inevitably rely heavily on the skills of physicists and physics-trained engineers.

## 3: Conclusions

In summary, the findings of the survey, along with other recent research work, show the following:

- Physics graduates from Scottish institutions enjoy varied career paths, both in Scotland and overseas.
- They earn well above the average UK wage.
- They succeed in management positions and consultancy.
- More than half of physics graduates who also obtained a PhD in physics now earn a salary in excess of £50 000.
- Physics-based industry is a critical element of the Scottish economy; 4% of the workforce provides nearly 10% of the GVA.

These findings have also highlighted some causes for concern:

- The financial rewards on offer to the best physics graduates outside the teaching sector are far in excess of those within teaching.
- Female physics graduates are less likely to reach the best-paid positions than their male counterparts.
- The supply of science teachers specialising in physics must be at least maintained, and ideally increased.
- The number of students taking the physics Higher examination in Scotland remains historically low.
- Talented physics graduates can find lucrative employment around the world, and may leave local economies if opportunities are restricted.

### Recommendations for policymakers

In the light of these findings, key actions for policymakers in Scotland are:

- Provide attractive opportunities to retain talented physics graduates within the Scottish economy.
- Ensure equality of opportunities for male and female graduates.
- Deliver careers guidance that focuses on the significant opportunities on offer to physics graduates, their high economic impact and the potential for overseas employment.
- Provide appropriate incentives to attract and retain specialist physics teachers.

# Appendix: Survey methodology

This report examines the findings of a survey of physics graduates from Scottish universities conducted through an online poll in 2009.

In all, 871 responses were received from graduates of all ages, at first degree and postgraduate level. As a comparison, in 2006/7, 300 physics degrees were awarded to graduates from Scottish institutions; 210 first degrees, 80 postgraduate qualifications,

including 50 PhDs and the remainder undergraduate diplomas.

The survey was delivered through a website and consisted of 10 questions with multiple responses. Unless otherwise explicitly stated, all references to physics qualifications refer to those obtained from Scottish institutions.

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- 4 *Annual Survey of Hours and Earnings (AHSE)*, 2008
- 5 *The Economic Benefits of Higher Education Qualifications* PWC/IOP/RSC 2005
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### **Acknowledgement**

We are most grateful to Iain Ross and Stephen McGeoch for suggesting the research and conducting the survey of physics graduates. We would also like to thank Allan Colquhoun and the IOP in Scotland branch committee for suggestions and advice.

# **Physics in Scotland:** the brightest minds go further

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