

# **INSTITUTE AND FACULTY OF ACTUARIES**

**Curriculum 2019**

**SPECIMEN SOLUTIONS**

**Subject SP9 – Enterprise Risk Management  
Specialist Principles**

**Q1** (i)

- Performance management purposes [1]
- To inform salary and bonuses [½]
- To determine an appropriate return on capital for each business/product line [1]
- To identify underperforming businesses/product lines and close these [½]
- To improve pricing (allow more appropriately for cost of capital) [½]
- Efficient use of capital: not leaving it unused at Group level [1]
- To manage and optimise risks holistically across the Group [½]
- To impose risk-based restrictions on the amount of business that can be written in each business area/product line [½]
- To optimise the risk/return balance [½]
- Helps the company to better understand diversification benefits [½]

[Maximum 3]

(ii)

- Country X = \$12.67m (=  $19 \times 66 / 99$ )
- Country Y = \$33.33m (=  $50 \times 66 / 99$ )
- Country Z = \$20.00m (=  $30 \times 66 / 99$ )

[2 marks for all three correct, 1½ marks for 1 error,  
1 mark for 2 errors, 0 if all wrong, maximum 2]

(iii) *Advantages*

- Allocates the diversification benefit (i.e. diversification across the three operations) back to the operating entities rather than keeping it at Group level... [1]
- ... which would not be a particularly efficient use of capital... [½]
- ... and could make the operations uncompetitive. [½]
- Simple to calculate [½]
- Simple to explain/understand [½]
- No additional calculations required at operations level (as regulatory capital is already determined) [1]
- Proportionate to the standalone capital requirements, i.e. takes into account the individual business's regulatory needs as the starting point [½]

*Disadvantages*

- Makes allowance for the diversification benefit in proportion to the individual capital requirements rather than in proportion to the marginal level of diversification contributed by each operation... [1]
- ... which may be deemed to be unfair by the operation which contributes the greatest diversification at Group level. [½]
- Capital requirement calculations can differ between countries as the local regulatory standard is used. Inconsistencies in the local approaches may mean the allocation may not be as fair as intended. [1]

- Results have to be converted from two other different currencies into the Group currency. There is no allowance for the risk of currency fluctuations in the method chosen. [1]
- The approach does not consider return on capital, so may not optimise return on capital employed. [1]

[Maximum 5]

(iv)

- X = equity market crash / significant storm event
- Y = economic downturn affecting both interest rates and credit spreads / pandemic
- Z = economic downturn affecting both interest rates and credit spreads / significant storm event

[½ mark per valid scenario,  
maximum 1 mark for each operation, maximum 3]

(v)

- Could bring market instability... [1]
- ...at least in the short term [1]
- And increase the risks to Purple Ltd [½]
- In particular, there is a risk that country Y's currency could devalue. [1]
- Any assets held in this currency will lose value if this happens, [½]
- So country Y stockmarket values may fall or become more volatile to reflect this devaluation risk. [1]
- Interest rates may also become more volatile... [½]
- ...or move adversely, i.e. increased interest rate risk. [½]
- Credit risk may also increase for corporates... [½]
- ...or for the government [½]
- The bulk of Purple plc's market and credit risks come from Country Y... [½]
- ...suggesting that the bulk of the assets are in Country Y currency, so this is a significant additional risk. [½]
- Market risk is exacerbated by any mismatching between assets and liabilities... [½]
- ...for example, by currency [½]
- There is a risk that there will be insufficient availability of suitable assets in Hip Island for matching purposes. [1]
- There will be greater uncertainty in relation to future inflation rates... [1]
- ... and future investment returns for the two separate parts of country Y ... [½]
- ... given that the economic potential of each country on a standalone basis is less certain than at present [½]
- New business / renewal risk may increase [½]
- The publicity and uncertainty may lead policyholders to behave unexpected ways [½]
- E.g. as mass lapses... [1]

- ...or extremely low renewals [1]
- Or a reduction in new business [½]
- Or even panic policy buying may occur [½]
- There is increased political risk... [½]
- ...which may result in nationalisation [1]
- There is a risk that the new government of Hip Island will bar Purple Ltd from selling business there anymore... [1]
- ... in order to promote its own local insurers [½]
- Changes to State interventions could also impact the demand for insurance products... [½]
- ...for example, in relation to tax incentives (or some other valid example)
- Insurance risk may increase [½]
- In the longer term claims experience may be different to Hiponia, requiring different demographic assumptions. [½]
- It may be difficult to price accurately for the different populations... [½]
- ...depending on the extent to which experience data is available. [½]
- Certain risks may increase if contract terms are not changed in line with any new requirements... [½]
- ... e.g. legal, reputational (or other valid example) [½]
- There is increased regulatory risk... [½]
- ... since new regulations could be introduced to Hip Island that are different to those in Hiponia. [1]
- Operational risks may increase [1]
- e.g. if Purple Ltd is required to (or decides to) set up new operations in Hip Island [½]
- And due to the systems developments/changes that will be required (new currency etc.) [½]
- Expense risk increases... [½]
- ...due to the uncertainties involved in what is needed for the above changes [½]
- There may be increased counterparty default risk... [½]
- ... e.g. if an outsourcer is no longer able to provide the service across borders [½]
- Restrictions on repatriation of profits (currency controls) [½]
- There may also be upside risks, presenting opportunities [½]
- Existing mitigations may be less effective [½]
- Model risk may increase (e.g. in the pricing model) [½]
- There may be liquidity risk [½]
- Increased strategic risk [½]

[Maximum 10]

(vi)

- Hold additional capital
- Temporarily stop writing new business in country Y
- Issue public statements to reassure policyholders
- Assess the proposals being made by the intended new government if independence was to go ahead

- Consider changing asset strategy
- i.e. switching assets into more stable asset classes
- or improving bond quality
- and possibly switching into a different currency
- Use derivatives to hedge against expected adverse economic changes
- Develop a project plan for the operational changes that will need to be made if independence goes ahead
- Analyse historic experience data split by Hiponia and Hip Island
- Use reinsurance
- Use outsourcing
- Reduce guarantees on new business
- Sell off the island business
- Set up a branch office on the island
- Securitise the island business
- Investigate other opportunities

[1 mark per point for the first two valid points,  
then ½ mark per point, maximum 4]

(vii)

- A marginal approach may be more appropriate [1]
- In particular, allocating capital to the country Y operations in line with its marginal contribution [1]
- Should also split country Y down further into the capital required for the Hip Island business and the capital required for the Hiponia business, and allocate capital separately to each [1]
- Closing to new business could materially change the degree of diversification between the operations in country Y and those in the other countries, thus making it more important to understand the relative contributions of each set of operations [1]
- It also may be the case that country Y could sell off its closed business in Hip Island (or even also in Hiponia) post-independence, so understanding the marginal capital requirement would be important [1]

[Maximum 3]

[Total 30]

**Q2** (i)

- On the face of it, the 30 mph average speed suggests that this site offers sufficient wind power to be profitable, since it exceeds the 25 mph minimum requirement [1]
- However, there is no allowance for risk in this assessment [1]
- It would therefore be helpful to know the degree of confidence for the estimation of the average speed [½]
- And the standard deviation (or distribution) of the averages [1]
- The data on which the assessment is based are also limited [1]

- For example, it is important to note that the 200 day sampling period does not cover a full calendar year, and so may not be representative [1]
- If the period excluded the least windy season, then the average speed achievable over a full year could be lower (and too low to be profitable)[1]
- If the period excluded the windy season, then there is a risk that the wind could be above 75 miles per hour for longer, again reducing the “useful” average speed [1]
- So at least a full year of data should ideally be used [½]
- Even a single year might not be representative... [½]
- ... e.g. due to an unusually active storm event or storm season ... [½]
- So it would be wise to collect several years of data [½]
- Information may be required on the accuracy of the recording equipment... [½]
- ... particularly in relation to the recording of high wind speeds
- Trends should also be analysed if possible ... [1]
- ... and allowed for in a future projection ... [½]
- ... e.g. due to climate change [½]
- High level information from the country’s meteorological service may be required for the trend analysis [½]
- But this may not be available for or relevant to this particular location
- It would also be helpful to know how much confidence there was in the 25 year life time for the turbines [½]
- This includes both the accuracy of the average itself (e.g. based on the length of time that the turbines and their components had been in service, and the number of such turbines that existed) and the standard deviation (or distribution) of this figure [1]
- Other information required would include the impact that the remoteness of the land has on costs [½]
- And whether this remoteness would lead to more downtime in the event of a problem with one or more of the turbines [½]
- And information of the wider suitability of the site, including the quality of the land... [½]
- ... and access to it [½]
- Though the remoteness could be positive if it leads to less local resistance [½]
- Should seek information on the possibility of adverse environmental factors (e.g. near a protected beauty spot or bird nesting area) [½]
- And political factors (e.g. possibility of protests) [½]
- Could compare the data from this site against data from alternative potential sites [½]

[Maximum 7]

(ii)

- The statement is incorrect [1]
- The data only covered 200 days, so the results for a full year might include some days where there were high winds [1]

- More importantly, such winds might not occur every year, so multi-year analysis might expose some risk [1]
  - It is highly incorrect and dangerous to state that there is no risk just because something has not happened in the past: e.g. emerging risks, black swans [1]
  - There is no analysis of how the frequency of high winds has changed over time – climate change may make such winds more likely [1]
  - The 145mph wind speed quoted for the country may not have been measured anywhere near this specific location [½]
  - Equipment used decades ago may have been inaccurate [½]
  - The 150mph damage limit is an estimate, and 145mph is close to this level
  - The consultant should make use of additional data to draw a more realistic conclusion [½]
- Damage to wind turbines may occur from other causes... [½]
- ...e.g. bird strikes, vandalism etc. [½]

[Maximum 3]

(iii)

- Take the annual wind speed observations for Actuarial =  $\{X_n\}$  [½]
- Determine the appropriate threshold,  $u$  [½]
- This is done by determining where the “tail” of the distribution lies... [1]
- ... using the empirical mean excess function  $e(u)$  [½]
- ... given by  $e(u) = \text{sum}(X_n - u)I(X_n > u) / \text{sum } I(X_n > u)$  [½]
- This involves plotting  $e(u)$  against  $u$ ... [½]
- ... for various values of  $u$  [½]
- Look for the point at which this function becomes linear (which represents the start of the tail of the distribution) [½]
- Choose a value of  $u$  for which  $e(u)$  has become a linear function of  $u$  ...
- .... and remains so [½]
- Use the data for this value of  $u$  and above to fit the GPD... [½]
- ...to  $X_n - u$  (for  $X_n > u$ ) [½]
- Do this using a technique such as the method of moments or maximum likelihood estimation [1]
- Then evaluate the distribution function for wind speeds greater than 150mph. [½]
- 

[Maximum 4]

(iv) *Advantages*

- Winds of over 150 mph are extreme values, and the GPD is used for modelling extreme values (so is appropriate)
- It is not necessary to know the distribution of the wind speeds themselves
- Unlike the Generalised Extreme Value (GEV) return period approach, it does not need observations above the critical point to make an estimate

- Allows the possibility of winds over 150mph to be modelled even if they haven't yet been seen
- Uses data over a long time horizon
- GPD is a distribution, so gives confidence levels

*Disadvantages*

- The approach does not allow for the possibly changing nature of risk over time
- This might mean that the risk is understated
- It is not clear whether the national highest wind will be relevant for this site due to geographical considerations...
- ... and also noting that the highest wind speeds recorded in the country may occur in a number of different places so are not representative of a single site
- This might mean that the risk is overstated
- When applying the GPD method, the choice of threshold is difficult, and involves a subjective choice
- The observations are not necessarily independent

[1 mark for each of the first two valid points, then ½ marks per subsequent valid point, maximum 3]

(v)

- The company will need to determine  $Sp_{n,p}$ , the covariance between the profit in line  $n$  ( $P_n$ ) and the total profit ( $P$ ) ... [1]
- ... based on past observations [½]
- The historical profitability per unit of capital would therefore need to be assessed for each of the three power sources and in total... [1]
- ...with historical observations adjusted for inflation [½]
- Capital is then allocated in inverse proportion... [1]
- ... to the covariance that the profitability of each source of power generation has with the profitability from all sources. [½]  
(Give a mark for an alternative explanation using partial derivatives)
- The covariance with the total level of profitability will change with the allocation to each power source [½]
- An iterative approach is therefore needed [½]

[Maximum 3]

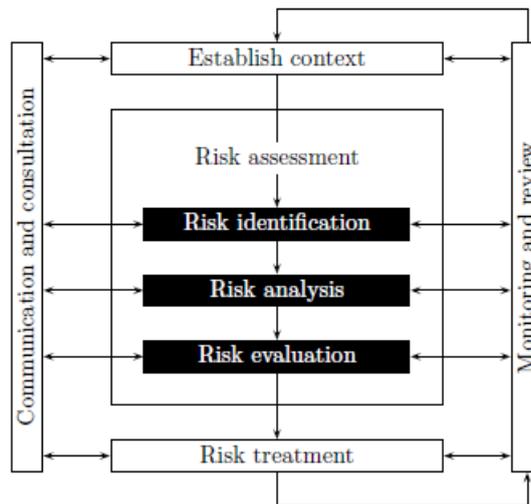
(vi)

- Using this approach allows both for the correlation of each power source with the total... [1]
- ...and the relative volatilities. [½]
- As such, it is a sensible (or fair) approach... [½]
- ...if profitability is jointly normally distributed... [½]
- ...and volatility of profitability is the main concern for the company. [½]
- Profitability may be non-normal... [½]
- ...and higher moments of the distribution will be ignored [1]

- If the risk of loss is more important than uncertainty over profitability... [1]
- ... then perhaps a VaR or Tail VaR based version of the Euler approach would be more appropriate [1]
- The Euler approach relies on data which might be unreliable (for example, difficulties determining covariance matrix)... [1]
- ...and could give difficulties in regards to communication to stakeholders... [½]
- ...in other words, it could be hard to explain or understand [1]

[Maximum 3]

(vii)



[3 marks for a diagram which is close to that above, 2 marks for something which is around two-thirds accurate, 1 mark for something which is around one-third accurate, 0 marks for something which bears no resemblance (or has not been tackled); ½ mark can be given between these levels. If e.g. the actuarial control cycle or the risk management control cycle is given, 2 marks should be awarded, maximum 3]

(viii)

- risk management should both create and protect value
- it should be an integral part of all processes in an organisation
- as such, it should also form a part in decision making processes
- it should address uncertainty explicitly
- the processes of risk management should be carried out in a systematic, structured and timely manner
- decisions taken should be based on the best available information;
- the approach to risk management should be tailored to the specific nature of the organisation
- this means it should take into account all human and cultural factors
- the approach should also be transparent, inclusive and relevant
- it should not be static – the process should be dynamic, iterative and should respond to changing needs; and

- it should facilitate the improvement of an organisation on a continuous basis

[1 mark each for the first three valid points, then ½ mark per subsequent valid point, maximum 4]

[Total 30]

**Q3** (i)

- A credit rating is a combination of letters and/or numbers... [½]
- ...given to an issuer of debt... [½]
- ... or to the debt issue itself... [½]
- ...by a credit rating agency... [½]
- ...that represents the likelihood that the debt will be repaid in full [1]

[Maximum 2]

(ii)

- The initial proportion of plants for each rating (A, B, C, D) is (0,0,1,0)... [½]
- ... assuming that plants which are already dead are ignored as they will not have produced any buds. [½]
- Multiply this vector by the transition matrix... [1]
- ... six times... [1]
- ... to get the final estimated proportion of flowers of each type A to D [½]  
(Or read off the third row of the transition matrix multiplied 6 times)
- The first entry of the new vector is the proportion of A-rated flowers [½]

[Maximum 3]

(iii)

- Stochastic modelling [1]
- Starting with the initial diameter of the newly opened flowers... [½]
- ... stochastically project the diameters of the flowers... [½]
- ... for six months... [½]
- ...using an assumed statistical distribution of growth rates based on the average and standard deviation provided ... [½]
- ...to give a distribution of flower diameters at the end of the six months
- Calculate the proportion of flowers with an A-rated diameter [½]

OR

- Deterministic approach using assumed normal distribution [1]
- Calculate the six-month average growth rate and the standard deviation from the monthly figures provided [1]
- Use the cumulative normal distribution based on these figures... [½]
- ... together with the initial diameter of the newly opened flowers... [½]
- ...to determine the estimated probability of a plant producing a flower which exceeds the A-rated diameter [½]
-

[Maximum 3]

(iv)

- Uncertainty of profit / the risk of loss is the key risk from both perspectives [1]
- However, the flower seller will be looking at a risk/return trade off... [1]
- ... in terms of the volume of flowers sold... [½]
- ... and price at which they can be sold (relative to the purchase price)... [½]
- ...versus the fixed costs incurred through borrowing [½]
- The greatest risk is of purchasing too many flowers and being unable to sell them at sufficient margin... [1]
- ...due to insufficient demand, poor quality flowers (or similar reason) [½]
- High volumes purchased will also result in a higher level of leverage... [½]
- ... which will result in a higher interest rate being charged by the bank. [½]
- In contrast, the banks will be more concerned with the risk of loss... [1]
- ... or at least the risk of profits being insufficient to meet the loan servicing and repayment costs... [1]
- ... since the potential upside for them is limited... [½]
- ... and the best case scenario is that there are no defaults [½]
- The banks may have greater control over the risk [1]
- Since they can turn down loan applications... [½]
- ...or charge a higher rate of interest... [½]
- ...or demand collateral [½]
- However, banks will also be exposed to concentration risk... [1]
- ... if they lend to lots of flower sellers who are adversely affected by (for example) a general fall in demand, and thus volume/price [½]
- However, banks will also be able to diversify the flower seller risks with other risks in their business (lending to different sectors, trading etc.) [1]

[Maximum 5]

(v)

- The risk of money markets not being able to supply funding to businesses when required (equivalently, the risk that an organisation cannot raise capital when needed) [1]
- Risk relating to the management of short term cash flow requirements [1]
- Insufficient capacity in the market to handle asset transactions at the time when a deal is required without a material impact on price [1]

[Maximum 2]

(vi)

- The flower seller may be unable to meet short term cash flow requirements... [1]
- ... such as payment of salaries to the two employees... [½]
- ... and payment of rent... [½]

- ... and payments to other creditors [½]
- In particular, the flower seller must cover the short-term interest payments on its loans [1]
- Liquidity risk may arise due to unexpected payments being needed [1]
- Or due to having insufficient cash inflows from flower sales to meet the expected outflows [1]
- Or due to having insufficient cash funds in reserve [1]
- The flower seller may be subject to liquidity risk if the short-term funding arrangement becomes unavailable... [1]
- ... or too expensive... [½]
- ... e.g. due to a wider banking liquidity crisis [½]
- ... or due to a change in the bank's view of the credit worthiness of the flower seller [½]
- The flower seller also may have to accept a substantially reduced flower price for a quick sale... [½]
- ... in order to meet short term cash outflows [½]
- If flowers are selling too slowly, they can be sold to the flower pressers in order to meet interest payments... [1]
- ...but this should be a last resort only since this generates a loss [½]
- And the flower presser may not make payments immediately [½]
- There may be seasonal variation in liquidity needs [½]

[Maximum 7]

(vii)

- Consider current funding and mix of business
- Allow for proposed advance purchase of flowers...
- ...and level of borrowing that this implies
- Choose timescale (e.g. 12 months)
- Build a cash flow model/project known cash out flows
- i.e. rent, wages, interest costs
- Also project income from flower sales
- And all expenditure relating to flowers
- The model should give output that reflects timing mismatches/allow for the timing mismatch
- It should reflect past internal experience/data where appropriate
- Seasonal variations should be allowed for
- Perform stress testing...
- ...e.g. changes in interest rates, flower sales
- And scenario testing to the extent that the cashflows are uncertain
- Particularly if interest rate costs are floating rate...
- ...or rent review coming up
- Include "worst case" scenarios
- E.g. loss of short-term funding
- E.g. serious contraction of flower-pressing industry
- Consider scenarios based on worst historical events in terms of flower prices and volumes...

- ...and allowing for “fire sale” (or “flower press”) values on advance purchased flowers...
- ...but scaled – e.g. half as many sales at lowest prices
- Actual factor will depend on historical volatility
- May need some expert input to set appropriate stress and scenario tests
- And external data similarly
- If sufficient data are available...
- ...consider stochastic modelling...
- ...but the fact that data are annual means that the relevance of earlier observations for stochastic modelling would be questionable
- Determine the confidence level at which the flower seller would expect to (just) have sufficient liquidity
- Allow for correlations with other risks
- E.g. interest rate risk

[1 mark each for the first four valid points,  
then ½ mark per subsequent valid point, maximum 8]

(viii)

- Reduce the level of borrowing
- Sell fewer flowers
- Change the mix of business, between high and lower value flowers
- Make greater use of the flower presser option for sales
- Use forwards/futures
- Form a co-operative society
- Arrange emergency overdraft facilities
- Hold higher cash reserves
- Close monitoring of cash flows
- Active creditor/debtor management
- Ensure that the two employees are aware of the importance of liquidity management
- Take advance customer orders
- Use casual labour
- Negotiate a reduced/partial payment to the growers
- Fix interest rates on the funding for more than one year
- Diversify into other goods/services
- Find alternative funding
- Link staff salaries to sales volumes
- Negotiate lower rent (or another “cost cutting” point)

[1 mark each for the first two valid points,  
then ½ mark per subsequent valid point, maximum 4]

(ix)

- All organisations can benefit from an ERM framework... [1]  
...though the level of complexity/detail will depend on the size and complexity of the organisation [1]
- And cost considerations need to be taken into account [1]
- It is important to view risks holistically... [1]
- ... so that any concentrations of risk can be recognised... [1]
- ...as well as any diversification potential [1]
- It is also important to set out the risk appetite... [1]
  
- ... and to determine whether the level of risk being taken is consistent with this [1]
- It is also important to mitigate excessive risks where these do exist. [1]
- For an organisation with only three employees, it is particularly important to have some form of risk management process in place... [1]
- ... as the organisation may struggle to cope if one of the employees cannot work... [1]
- ... and because it can be easier for the inappropriate actions of an individual to bring down the company than in a larger organisation [1]
- Without the framework, the manager may be too dominant... [1]
- ... and not subject to sufficient challenge from the two employees in terms of decisions being made [1]
- Decisions on the number of flowers to buy and the amount of borrowing to take on would be best made within a risk management framework... [1]
- ...since this affects not only profitability and solvency but also liquidity [1]
- This does not mean that all risks would need to be analysed quantitatively – qualitative may be more appropriate in some cases. [1]
- Having some form of risk management framework may result in lower borrowing costs [1]
- Would be useful simply to keep a risk register. [1]
- And educate/increase risk awareness/bring in risk management culture of/for the employees. [1]
- ERM can help to identify opportunities to exploit. [1]
- Would help to prepare for future expansion, as may not stay small forever [1]

[Maximum 6]

[Total 40]

**END OF SOLUTIONS**