

**Revision checklist**

The tables below can be used as a revision checklist: **It doesn’t contain all the detailed knowledge you need to know, just an overview.**

For more detail see the syllabus and talk to your teacher.

[A Level Further Mathematics A – H245 specification.](https://www.ocr.org.uk/Images/308752-specification-accredited-a-level-gce-further-mathematics-a-h245.pdf)

The table headings are explained below:

| **OCR Reference.** | **Content Description**(unshaded content is AS content) | **R** | **A** | **G** | **Notes** |
| --- | --- | --- | --- | --- | --- |
| Each item of content has a unique specification reference code.* **Mathematics A – H240**
1. Mathematics A: Pure
2. Mathematics A: Statistics
3. Mathematics A: Mechanics
* **Further Mathematics A – H245**
1. Further Mathematics A: Pure Core
2. Further Mathematics A: Statistics Option
3. Further Mathematics A: Mechanics Option
4. Further Mathematics A: Discrete Option
5. Further Mathematics A: Additional Pure
 | You can use the tick boxes to show when you have revised an item and how confident you feel about it.R = **RED** means you are really unsure and lack confidence; you might want to focus your revision here and possibly talk to your teacher for helpA = **AMBER** means you are reasonably confident but need some extra practiceG = **GREEN** means you are very confident.As your revision progresses, you can concentrate on the **RED** and **AMBER** items in order to turn them into **GREEN** items. You might find it helpful to highlight each topic in red, orange or green to help you prioritise. |  You can use the notes column to:* add more information about the details for each point
* add formulae or notes
* include a reference to a useful resource.
* Highlight areas of difficulty or things that you need to talk to your teacher about or look up in a textbook.
 |

You must be able to use all the formulae and identities given for the Pure Core mandatory strand of A Level Further Mathematics, without those formulae and identities being provided, either in these forms or in equivalent forms. Those formulae and identities may only be provided where they are the starting point for a proof or as a result to be proved.

Additionally, for the statistics option, you must know and be able to use the following

**Statistics**

The mean of a set of data: 

The standard Normal variable: where 

Learners will be given a Formulae Booklet in each assessment which has both the A Level Mathematics and the A Level Further Mathematics formulae (the version used for AS has only the AS Maths and Further Maths formulae).

**Statistics option formulae**

**Probability

 or **

**Standard deviation** **or** 

**Sampling distributions**For any variable , ,  and is approximately normally distributed when *n* is large enough (approximately )

If  then  and 
Unbiased estimates of the population mean and variance are given by  and 

**Expectation algebra**
Use the following results, including the cases where  and/or :
1. ,
2. if *X* and *Y* are independent then .
**Discrete distributions***X* is a random variable taking values  in a discrete distribution with 
Expectation: 
Variance: 

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| Binomial  |  | *np* | *np*(1 – *p*) |
| Uniform distribution over 1, 2, …, *n*,  |  |  |  |
| Geometric distribution  |  |  |  |
| Poisson  |  |  |  |

**Continuous distributions***X* is a continuous random variable with probability density function (p.d.f.) 

Expectation: 

Variance: 

Cumulative distribution function 

|  |  |  |  |
| --- | --- | --- | --- |
|  | p.d.f. |  |  |
| Continuous uniform distribution over  |  |  |  |
| Exponential |  |  |  |
| Normal  |  |  |  |

**Percentage points of the normal distribution**If *Z* has a normal distribution with mean 0 and variance 1 then, for each value of *p*, the table gives the value of *z* such that .

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *p* | 0.75 | 0.90 | 0.95 | 0.975 | 0.99 | 0.995 | 0.9975 | 0.999 | 0.9995 |
| *z* | 0.674 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 2.807 | 3.090 | 3.291 |

 **Non-parametric tests**Goodness-of-fit test and contingency tables: 
Approximate distributions for large samples

 Wilcoxon Signed Rank test: 

 Wilcoxon Rank Sum test (samples of sizes *m* and *n*, with ) : 

**Correlation and regression**For a sample of *n* pairs of observations 
,


Product-moment correlation coefficient: 

The regression coefficient of *y* on *x* is 

Least squares regression line of *y* on *x* is  where 

Spearman’s rank correlation coefficient: 

|  |  |
| --- | --- |
| **Critical values for the product moment correlation coefficient, *r*** | **Critical values for Spearman’s rank correlation coefficient, *rs*** |
|  | 5% | 2½% | 1% | ½% | 1-Tail Test | 5% | 2½% | 1% | ½% |  |  |  | 5% | 2½% | 1% | ½% | 1-Tail Test | 5% | 2½% | 1% | ½% |
|  | 10% | 5% | 2% | 1% | 2-Tail Test | 10% | 5% | 2% | 1% |  |  |  | 10% | 5% | 2% | 1% | 2-Tail Test | 10% | 5% | 2% | 1% |
| *n* |  |  |  |  |  | *n* |  |  |  |  |  |  | *n* |  |  |  |  |  | *n* |  |  |  |  |
| 1 | - | - | - | - |  | 31 | 0.3009 | 0.3550 | 0.4158 | 0.4556 |  |  | 1 | - | - | - | - |  | 31 | 0.3012 | 0.3560 | 0.4185 | 0.4593 |
| 2 | - | - | - | - |  | 32 | 0.2960 | 0.3494 | 0.4093 | 0.4487 |  |  | 2 | - | - | - | - |  | 32 | 0.2962 | 0.3504 | 0.4117 | 0.4523 |
| 3 | 0.9877 | 0.9969 | 0.9995 | 0.9999 |  | 33 | 0.2913 | 0.3440 | 0.4032 | 0.4421 |  |  | 3 | - | - | - | - |  | 33 | 0.2914 | 0.3449 | 0.4054 | 0.4455 |
| 4 | 0.9000 | 0.9500 | 0.9800 | 0.9900 |  | 34 | 0.2869 | 0.3388 | 0.3972 | 0.4357 |  |  | 4 | 1.0000 | - | - | - |  | 34 | 0.2871 | 0.3396 | 0.3995 | 0.4390 |
| 5 | 0.8054 | 0.8783 | 0.9343 | 0.9587 |  | 35 | 0.2826 | 0.3338 | 0.3916 | 0.4296 |  |  | 5 | 0.9000 | 1.0000 | 1.0000 | - |  | 35 | 0.2829 | 0.3347 | 0.3936 | 0.4328 |
| 6 | 0.7293 | 0.8114 | 0.8822 | 0.9172 |  | 36 | 0.2785 | 0.3291 | 0.3862 | 0.4238 |  |  | 6 | 0.8286 | 0.8857 | 0.9429 | 1.0000 |  | 36 | 0.2788 | 0.3300 | 0.3882 | 0.4268 |
| 7 | 0.6694 | 0.7545 | 0.8329 | 0.8745 |  | 37 | 0.2746 | 0.3246 | 0.3810 | 0.4182 |  |  | 7 | 0.7143 | 0.7857 | 0.8929 | 0.9286 |  | 37 | 0.2748 | 0.3253 | 0.3829 | 0.4211 |
| 8 | 0.6215 | 0.7067 | 0.7887 | 0.8343 |  | 38 | 0.2709 | 0.3202 | 0.3760 | 0.4128 |  |  | 8 | 0.6429 | 0.7381 | 0.8333 | 0.8810 |  | 38 | 0.2710 | 0.3209 | 0.3778 | 0.4155 |
| 9 | 0.5822 | 0.6664 | 0.7498 | 0.7977 |  | 39 | 0.2673 | 0.3160 | 0.3712 | 0.4076 |  |  | 9 | 0.6000 | 0.7000 | 0.7833 | 0.8333 |  | 39 | 0.2674 | 0.3168 | 0.3729 | 0.4103 |
| 10 | 0.5494 | 0.6319 | 0.7155 | 0.7646 |  | 40 | 0.2638 | 0.3120 | 0.3665 | 0.4026 |  |  | 10 | 0.5636 | 0.6485 | 0.7455 | 0.7939 |  | 40 | 0.2640 | 0.3128 | 0.3681 | 0.4051 |
| 11 | 0.5214 | 0.6021 | 0.6851 | 0.7348 |  | 41 | 0.2605 | 0.3081 | 0.3621 | 0.3978 |  |  | 11 | 0.5364 | 0.6182 | 0.7091 | 0.7545 |  | 41 | 0.2606 | 0.3087 | 0.3636 | 0.4002 |
| 12 | 0.4973 | 0.5760 | 0.6581 | 0.7079 |  | 42 | 0.2573 | 0.3044 | 0.3578 | 0.3932 |  |  | 12 | 0.5035 | 0.5874 | 0.6783 | 0.7273 |  | 42 | 0.2574 | 0.3051 | 0.3594 | 0.3955 |
| 13 | 0.4762 | 0.5529 | 0.6339 | 0.6835 |  | 43 | 0.2542 | 0.3008 | 0.3536 | 0.3887 |  |  | 13 | 0.4835 | 0.5604 | 0.6484 | 0.7033 |  | 43 | 0.2543 | 0.3014 | 0.3550 | 0.3908 |
| 14 | 0.4575 | 0.5324 | 0.6120 | 0.6614 |  | 44 | 0.2512 | 0.2973 | 0.3496 | 0.3843 |  |  | 14 | 0.4637 | 0.5385 | 0.6264 | 0.6791 |  | 44 | 0.2513 | 0.2978 | 0.3511 | 0.3865 |
| 15 | 0.4409 | 0.5140 | 0.5923 | 0.6411 |  | 45 | 0.2483 | 0.2940 | 0.3457 | 0.3801 |  |  | 15 | 0.4464 | 0.5214 | 0.6036 | 0.6536 |  | 45 | 0.2484 | 0.2974 | 0.3470 | 0.3822 |
| 16 | 0.4259 | 0.4973 | 0.5742 | 0.6226 |  | 46 | 0.2455 | 0.2907 | 0.3420 | 0.3761 |  |  | 16 | 0.4294 | 0.5029 | 0.5824 | 0.6353 |  | 46 | 0.2456 | 0.2913 | 0.3433 | 0.3781 |
| 17 | 0.4124 | 0.4821 | 0.5577 | 0.6055 |  | 47 | 0.2429 | 0.2876 | 0.3384 | 0.3721 |  |  | 17 | 0.4142 | 0.4877 | 0.5662 | 0.6176 |  | 47 | 0.2429 | 0.2880 | 0.3396 | 0.3741 |
| 18 | 0.4000 | 0.4683 | 0.5425 | 0.5897 |  | 48 | 0.2403 | 0.2845 | 0.3348 | 0.3683 |  |  | 18 | 0.4014 | 0.4716 | 0.5501 | 0.5996 |  | 48 | 0.2403 | 0.2850 | 0.3361 | 0.3702 |
| 19 | 0.3887 | 0.4555 | 0.5285 | 0.5751 |  | 49 | 0.2377 | 0.2816 | 0.3314 | 0.3646 |  |  | 19 | 0.3912 | 0.4596 | 0.5351 | 0.5842 |  | 49 | 0.2378 | 0.2820 | 0.3326 | 0.3664 |
| 20 | 0.3783 | 0.4438 | 0.5155 | 0.5614 |  | 50 | 0.2353 | 0.2787 | 0.3281 | 0.3610 |  |  | 20 | 0.3805 | 0.4466 | 0.5218 | 0.5699 |  | 50 | 0.2353 | 0.2791 | 0.3293 | 0.3628 |
| 21 | 0.3687 | 0.4329 | 0.5034 | 0.5487 |  | 51 | 0.2329 | 0.2759 | 0.3249 | 0.3575 |  |  | 21 | 0.3701 | 0.4364 | 0.5091 | 0.5558 |  | 51 | 0.2329 | 0.2764 | 0.3260 | 0.3592 |
| 22 | 0.3598 | 0.4227 | 0.4921 | 0.5368 |  | 52 | 0.2306 | 0.2732 | 0.3218 | 0.3542 |  |  | 22 | 0.3608 | 0.4252 | 0.4975 | 0.5438 |  | 52 | 0.2307 | 0.2736 | 0.3228 | 0.3558 |
| 23 | 0.3515 | 0.4132 | 0.4815 | 0.5256 |  | 53 | 0.2284 | 0.2706 | 0.3188 | 0.3509 |  |  | 23 | 0.3528 | 0.4160 | 0.4862 | 0.5316 |  | 53 | 0.2284 | 0.2710 | 0.3198 | 0.3524 |
| 24 | 0.3438 | 0.4044 | 0.4716 | 0.5151 |  | 54 | 0.2262 | 0.2681 | 0.3158 | 0.3477 |  |  | 24 | 0.3443 | 0.4070 | 0.4757 | 0.5209 |  | 54 | 0.2262 | 0.2685 | 0.3168 | 0.3492 |
| 25 | 0.3365 | 0.3961 | 0.4622 | 0.5052 |  | 55 | 0.2241 | 0.2656 | 0.3129 | 0.3445 |  |  | 25 | 0.3369 | 0.3977 | 0.4662 | 0.5108 |  | 55 | 0.2242 | 0.2659 | 0.3139 | 0.3460 |
| 26 | 0.3297 | 0.3882 | 0.4534 | 0.4958 |  | 56 | 0.2221 | 0.2632 | 0.3102 | 0.3415 |  |  | 26 | 0.3306 | 0.3901 | 0.4571 | 0.5009 |  | 56 | 0.2221 | 0.2636 | 0.3111 | 0.3429 |
| 27 | 0.3233 | 0.3809 | 0.4451 | 0.4869 |  | 57 | 0.2201 | 0.2609 | 0.3074 | 0.3385 |  |  | 27 | 0.3242 | 0.3828 | 0.4487 | 0.4915 |  | 57 | 0.2201 | 0.2612 | 0.3083 | 0.3400 |
| 28 | 0.3172 | 0.3739 | 0.4372 | 0.4785 |  | 58 | 0.2181 | 0.2586 | 0.3048 | 0.3357 |  |  | 28 | 0.3180 | 0.3755 | 0.4401 | 0.4828 |  | 58 | 0.2181 | 0.2589 | 0.3057 | 0.3370 |
| 29 | 0.3115 | 0.3673 | 0.4297 | 0.4705 |  | 59 | 0.2162 | 0.2564 | 0.3022 | 0.3328 |  |  | 29 | 0.3118 | 0.3685 | 0.4325 | 0.4749 |  | 59 | 0.2162 | 0.2567 | 0.3030 | 0.3342 |
| 30 | 0.3061 | 0.3610 | 0.4226 | 0.4629 |  | 60 | 0.2144 | 0.2542 | 0.2997 | 0.3301 |  |  | 30 | 0.3063 | 0.3624 | 0.4251 | 0.4670 |  | 60 | 0.2144 | 0.2545 | 0.3005 | 0.3314 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Critical values for the distribution**

|  |  |
| --- | --- |
| If *X* has a  distribution with *v* degrees of freedom then, for each pair of values of *p* and *v*, the table gives the value of *x* such that. | *p**x**O* |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *p* | 0.01 | 0.025 | 0.05 | 0.90 | 0.95 | 0.975 | 0.99 | 0.995 | 0.999 |
|  | 0.031571 | 0.039821 | 0.023932 | 2.706 | 3.841 | 5.024 | 6.635 | 7.879 | 10.83 |
| 2 | 0.02010 | 0.05064 | 0.1026 | 4.605 | 5.991 | 7.378 | 9.210 | 10.60 | 13.82 |
| 3 | 0.1148 | 0.2158 | 0.3518 | 6.251 | 7.815 | 9.348 | 11.34 | 12.84 | 16.27 |
| 4 | 0.2971 | 0.4844 | 0.7107 | 7.779 | 9.488 | 11.14 | 13.28 | 14.86 | 18.47 |
| 5 | 0.5543 | 0.8312 | 1.145 | 9.236 | 11.07 | 12.83 | 15.09 | 16.75 | 20.51 |
| 6 | 0.8721 | 1.237 | 1.635 | 10.64 | 12.59 | 14.45 | 16.81 | 18.55 | 22.46 |
| 7 | 1.239 | 1.690 | 2.167 | 12.02 | 14.07 | 16.01 | 18.48 | 20.28 | 24.32 |
| 8 | 1.647 | 2.180 | 2.733 | 13.36 | 15.51 | 17.53 | 20.09 | 21.95 | 26.12 |
| 9 | 2.088 | 2.700 | 3.325 | 14.68 | 16.92 | 19.02 | 21.67 | 23.59 | 27.88 |
| 10 | 2.558 | 3.247 | 3.940 | 15.99 | 18.31 | 20.48 | 23.21 | 25.19 | 29.59 |
| 11 | 3.053 | 3.816 | 4.575 | 17.28 | 19.68 | 21.92 | 24.73 | 26.76 | 31.26 |
| 12 | 3.571 | 4.404 | 5.226 | 18.55 | 21.03 | 23.34 | 26.22 | 28.30 | 32.91 |
| 13 | 4.107 | 5.009 | 5.892 | 19.81 | 22.36 | 24.74 | 27.69 | 29.82 | 34.53 |
| 14 | 4.660 | 5.629 | 6.571 | 21.06 | 23.68 | 26.12 | 29.14 | 31.32 | 36.12 |
| 15 | 5.229 | 6.262 | 7.261 | 22.31 | 25.00 | 27.49 | 30.58 | 32.80 | 37.70 |
| 16 | 5.812 | 6.908 | 7.962 | 23.54 | 26.30 | 28.85 | 32.00 | 34.27 | 39.25 |
| 17 | 6.408 | 7.564 | 8.672 | 24.77 | 27.59 | 30.19 | 33.41 | 35.72 | 40.79 |
| 18 | 7.015 | 8.231 | 9.390 | 25.99 | 28.87 | 31.53 | 34.81 | 37.16 | 42.31 |
| 19 | 7.633 | 8.907 | 10.12 | 27.20 | 30.14 | 32.85 | 36.19 | 38.58 | 43.82 |
| 20 | 8.260 | 9.591 | 10.85 | 28.41 | 31.41 | 34.17 | 37.57 | 40.00 | 45.31 |
| 21 | 8.897 | 10.28 | 11.59 | 29.62 | 32.67 | 35.48 | 38.93 | 41.40 | 46.80 |
| 22 | 9.542 | 10.98 | 12.34 | 30.81 | 33.92 | 36.78 | 40.29 | 42.80 | 48.27 |
| 23 | 10.20 | 11.69 | 13.09 | 32.01 | 35.17 | 38.08 | 41.64 | 44.18 | 49.73 |
| 24 | 10.86 | 12.40 | 13.85 | 33.20 | 36.42 | 39.36 | 42.98 | 45.56 | 51.18 |
| 25 | 11.52 | 13.12 | 14.61 | 34.38 | 37.65 | 40.65 | 44.31 | 46.93 | 52.62 |
| 30 | 14.95 | 16.79 | 18.49 | 40.26 | 43.77 | 46.98 | 50.89 | 53.67 | 59.70 |
| 40 | 22.16 | 24.43 | 26.51 | 51.81 | 55.76 | 59.34 | 63.69 | 66.77 | 73.40 |
| 50 | 29.71 | 32.36 | 34.76 | 63.17 | 67.50 | 71.42 | 76.15 | 79.49 | 86.66 |
| 60 | 37.48 | 40.48 | 43.19 | 74.40 | 79.08 | 83.30 | 88.38 | 91.95 | 99.61 |
| 70 | 45.44 | 48.76 | 51.74 | 85.53 | 90.53 | 95.02 | 100.4 | 104.2 | 112.3 |
| 80 | 53.54 | 57.15 | 60.39 | 96.58 | 101.9 | 106.6 | 112.3 | 116.3 | 124.8 |
| 90 | 61.75 | 65.65 | 69.13 | 107.6 | 113.1 | 118.1 | 124.1 | 128.3 | 137.2 |
| 100 | 70.06 | 74.22 | 77.93 | 118.5 | 124.3 | 129.6 | 135.8 | 140.2 | 149.4 |

**Wilcoxon signed rank test**

** is the sum of the ranks corresponding to the positive differences,

** is the sum of the ranks corresponding to the negative differences,

*T* is the smaller of **and **.

For each value of *n* the table gives the **largest** value of *T* which will lead to rejection of the null hypothesis at the level of significance indicated.

**Critical values of *T***

|  |  |
| --- | --- |
|  | Level of significance |
| One Tail | 0.05 | 0.025 | 0.01 | 0.005 |
| Two Tail | 0.10 | 0.05 | 0.02 | 0.01 |
| *n* 6 |  2 |  0 |  |  |
|  7 |  3 |  2 |  0 |  |
|  8 |  5 |  3 |  1 |  0 |
|  9 |  8 |  5 |  3 |  1 |
|  10 | 10 |  8 |  5 |  3 |
|  11 | 13 | 10 |  7 |  5 |
|  12 | 17 | 13 |  9 |  7 |
|  13 | 21 | 17 | 12 |  9 |
|  14 | 25 | 21 | 15 | 12 |
|  15 | 30 | 25 | 19 | 15 |
|  16 | 35 | 29 | 23 | 19 |
|  17 | 41 | 34 | 27 | 23 |
|  18 | 47 | 40 | 32 | 27 |
|  19 | 53 | 46 | 37 | 32 |
|  20 | 60 | 52 | 43 | 37 |

For larger values of *n*, each of ** and **can be approximated by the normal distribution with mean  and variance .

**Wilcoxon rank sum test**

The two samples have sizes *m* and *n*, where .

** is the sum of the ranks of the items in the sample of size *m*.

*W* is the smaller of ** and .

For each pair of values of *m* and *n*, the table gives the **largest** value of *W* which will lead to rejection of the null hypothesis at the level of significance indicated.

**Critical values of *W***

|  |  |
| --- | --- |
|  | Level of significance |
| One Tail | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 |
| Two Tail | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 |
| *n* |  |  |  |  |
| 3 | 6 | - | - |  |  |  |  |  |  |  |  |  |
| 4 | 6 | - | - | 11 | 10 | - |  |  |  |  |  |  |
| 5 | 7 | 6 | - | 12 | 11 | 10 | 19 | 17 | 16 |  |  |  |
| 6 | 8 | 7 | - | 13 | 12 | 11 | 20 | 18 | 17 | 28 | 26 | 24 |
| 7 | 8 | 7 | 6 | 14 | 13 | 11 | 21 | 20 | 18 | 29 | 27 | 25 |
| 8 | 9 | 8 | 6 | 15 | 14 | 12 | 23 | 21 | 19 | 31 | 29 | 27 |
| 9 | 10 | 8 | 7 | 16 | 14 | 13 | 24 | 22 | 20 | 33 | 31 | 28 |
| 10 | 10 | 9 | 7 | 17 | 15 | 13 | 26 | 23 | 21 | 35 | 32 | 29 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Level of significance |
| One Tail | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 | 0.05 | 0.025 | 0.01 |
| Two Tail | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 | 0.1 | 0.05 | 0.02 |
| *n* |  |  |  |  |
| 7 | 39 | 36 | 34 |  |  |  |  |  |  |  |  |  |
| 8 | 41 | 38 | 35 | 51 | 49 | 45 |  |  |  |  |  |  |
| 9 | 43 | 40 | 37 | 54 | 51 | 47 | 66 | 62 | 59 |  |  |  |
| 10 | 45 | 42 | 39 | 56 | 53 | 49 | 69 | 65 | 61 | 82 | 78 | 74 |

For larger values of *m* and *n*, the normal distribution with mean  and variance  should be used as an approximation to the distribution of *.*

### Content of Statistics (Optional paper Y542)

| **OCR Reference** | **Content Description**(unshaded content is AS content) | **R** | **A** | **G** | **Notes** |
| --- | --- | --- | --- | --- | --- |
| **5.01a** | a) Be able to evaluate probabilities by calculation using permutations and combinations.*Includes the terms permutation and combination*.*Includes the notation*  *and*  *.**For underlying content on probability see H240 section 2.03.* |  |  |  |  |
| **5.01b** | b) Be able to evaluate probabilities by calculation in contexts involving selections and arrangements.*Selection problems include, for example, finding the probability that 3 vowels and 2 consonants are chosen when 5 letters are chosen at random from the word ‘CALCULATOR’.* *Arrangement problems only involve arrangement of objects in a line and include**1. repetition, e.g. the probability that the word*  *‘ARTIST’ is formed when the letters of the word*  *‘STRAIT’ are chosen at random.**2. restriction, e.g. the probability that two consonants*  *are (or are not) next to each other when the letters*  *of the word ‘TRAITS’ are placed in a random order.* |  |  |  |  |
| **5.02a** | a) Understand and be able to use discrete probability distributions.*Includes using and constructing probability distribution tables and functions relating to a given situation involving a discrete random variable.**Any defined non-standard distribution will be finite.* |  |  |  |  |
| **5.02b** | b) Understand and be able to calculate the expectation and variance of a discrete random variable.*Includes knowing and be able to use the formulae*[*Proof of these results is excluded.*] |  |  |  |  |
| **5.02c** | c) Know and be able to use the effects of linear coding on the mean and variance of a random variable. |  |  |  |  |
| **5.02d** | d) Know and be able to use the formulae and  for a binomial distribution.*[Proof of these results is excluded.]**For the underlying content on binomial distributions, see H240 sections 2.04b and 2.04c.* |  |  |  |  |
| **5.02e** | e) Know and be able to use the conditions under which a random variable will have a discrete uniform distribution, and be able to calculate probabilities and the mean and variance for a given discrete uniform distribution.*Includes use of the notation* *for the uniform distribution over the interval* . |  |  |  |  |
| **5.02f** | f) Know and be able to use the conditions under which a random variable will have a geometric distribution.*Includes use of the notation* *, where X is the number of trials up to and including the first success.* |  |  |  |  |
| **5.02g** | g) Be able to calculate probabilities using the geometric distribution.*Learners may use the formulae*  *and* *.* |  |  |  |  |
| **5.02h** | h) Know and be able to use the formulae and  for a geometric distribution.[*Proof of these results is excluded.*] |  |  |  |  |
| **5.02i** | i) Understand informally the relevance of the Poisson distribution to the distribution of random events, and be able to use the Poisson distribution as a model.*Includes use of notation*  *, where X is the number of events in a given interval.* |  |  |  |  |
| **5.02j** | j) Understand and be able to use the formula . |  |  |  |  |
| **5.02k** | k) Be able to calculate probabilities using the Poisson distribution, using appropriate calculator functions.*Learners are expected to have a calculator with the ability to access probabilities from the Poisson distribution.*[*Use of the Poisson distribution to calculate numerical approximations for a binomial distribution is excluded.*] |  |  |  |  |
| **5.02l** | l) Know and be able to use the conditions under which a random variable will have a Poisson distribution.*Learners will be expected to identify which of the modelling conditions [assumptions] is/are relevant to a given scenario and to explain them in context.* |  |  |  |  |
| **5.02m** | m) Be able to use the result that if  then the mean and variance of *X* are each equal to . |  |  |  |  |
| **5.02n** | n) Know and be able to use the result that the sum of independent Poisson variables has a Poisson distribution. |  |  |  |  |
| **5.03a** | a) Understand and be able to use the concept of a continuous random variable, a probability density function (p.d.f.) and a cumulative distribution function (c.d.f).*Includes the normal, continuous uniform and exponential distributions.* *Includes understanding informally the link between the exponential and Poisson distributions.**Includes knowing and being able to use the formula for the mean and variance of the continuous uniform and exponential distribution.**For the underlying content on normal distributions, see H240 sections 2.04e, 2.04f and 2.04g.* |  |  |  |  |
| **5.03b** | b) Be able to use a probability density function (including where defined piecewise) to solve problems involving probabilities.*Includes knowing and being able to use* . |  |  |  |  |
| **5.03c** | c) Be able to calculate the mean and/or variance of a distribution using the formulae  and . |  |  |  |  |
| **5.03d** | d) Be able to use the general result , where  is the probability density function of the continuous random variable *X* and  is a function of *X*. |  |  |  |  |
| **5.03e** | e) Be able to find and use a cumulative distribution function (including where defined piecewise) to solve problems involving probabilities.*Includes being able to use*  |  |  |  |  |
| **5.03f** | f) Know and be able to use the relationship between the probability density function, , and the cumulative distribution function, , and use either to evaluate the median, quartiles and other percentiles. |  |  |  |  |
| **5.03g** | g) Be able to find and use the cumulative distribution functions of related variables.*e.g. Given the c.d.f. of X, find the c.d.f. of Y and hence the p.d.f. of Y where* *.* |  |  |  |  |
| **5.04a** | a) Be able to use the following results, including the cases where  and/or :1. ,2. if *X* and *Y* are independent then . |  |  |  |  |
| **5.04b** | b) Be able to use the following results:1. If *X* has a normal distribution then  has a  normal distribution.2. If *X* and *Y* have independent normal distributions  then has a normal distribution. |  |  |  |  |
| **5.05a** | a) Know that for any randomly and independently selected sample, , of size  taken from a population, then for the sample mean : 1. , 2.  and 3.  is approximately normally distributed when *n* is  large (approximately ).[*Proof of these results is excluded.*] |  |  |  |  |
| **5.05b** | b) Know that unbiased estimates of the population mean and variance are given by  and  respectively.[*Proof of these results is excluded.*]*Only an informal understanding of “unbiased” is required.* |  |  |  |  |
| **5.05c** | c) Be able to use a normal distribution to carry out a hypothesis test for a population mean in the following cases.1. A sample drawn from a normal population of  known, given or assumed variance,2. A large sample drawn from any population with  known, given or assumed variance,3. A large sample, drawn from any population with  unknown variance. |  |  |  |  |
| **5.05d** | d) Be able to use a normal distribution to find a confidence interval for a population mean in each of the above cases. |  |  |  |  |
| **5.06a** | a) Be able to use a chi-squared ( ) test with the appropriate number of degrees of freedom to test for independence in a contingency table and interpret the results of such a test.*Rows or columns, as appropriate, should be combined so that each expected frequency is at least 5, and Yates’ correction should be used in the special case of a*  *table.**A table of critical values of the*  *distribution will be provided*.*Includes calculation of expected frequencies and contributions to the test statistic.**Questions may require candidates to calculate some expected frequencies and contributions to the test statistic, but will not involve lengthy calculations.* |  |  |  |  |
| **5.06b** | b) Be able to fit a theoretical distribution, as prescribed by a given hypothesis involving a given ratio, proportion or discrete uniform distribution, to given data.Q*uestions may require candidates to calculate some expected frequencies, but will not involve lengthy calculations*. |  |  |  |  |
| **5.06c** | c) Extend their knowledge of fitting distributions to other known or given discrete and continuous distributions.Q*uestions may require candidates to calculate some expected frequencies, but will not involve lengthy calculations*. |  |  |  |  |
| **5.06d** | c) Be able to use a  test with the appropriate number of degrees of freedom to carry out the corresponding goodness of fit test.*Where necessary, adjacent classes should be combined so that each expected frequency is at least 5.**A table of critical values of the* *distribution will be provided*. |  |  |  |  |
| **5.07a** | a) Understand what is meant by a non-parametric hypothesis test, appreciate situations where such tests are useful and be able to select an appropriate test. |  |  |  |  |
| **5.07b** | b) Understand the basis of sign tests, the Wilcoxon signed-rank test and the Wilcoxon rank-sum test (also known as the Mann-Whitney U test).*Tables of critical values of T and W will be provided*. *Learners should know the notation*  *and* *.* |  |  |  |  |
| **5.07c** | c) Be able to test a hypothesis concerning a population median using a single-sample sign test and a single-sample Wilcoxon signed-rank test.[*Problems in which observations coincide with the hypothetical population median are excluded.*] |  |  |  |  |
| **5.07d** | d) Understand the difference between a paired-sample test and a two-sample test, and be able to select the appropriate form of test when solving problems. |  |  |  |  |
| **5.07e** | e) Be able to test for identity of populations using a paired-sample sign test, a Wilcoxon matched-pairs signed-rank test and (for unpaired samples) a Wilcoxon rank-sum test.[*Problems involving tied ranks are excluded.*] |  |  |  |  |
| **5.07f** | f) Be able to carry out tests using the Wilcoxon signed-rank test and the Wilcoxon rank-sum test for large samples using the approximations:Wilcoxon signed-rank test Wilcoxon rank-sum test (samples of size  and  , with  ) .*Includes the use of continuity corrections.* |  |  |  |  |
| **5.08a** | a) Be able to calculate the product-moment correlation coefficient (pmcc) for a set of bivariate data; raw data or summarised data may be given.*Use of appropriate calculator functions is expected.**Learners will not be required to enter large amounts of data into a calculator during the examination.* |  |  |  |  |
| **5.08b** | b) Understand that the value of a correlation coefficient is unaffected by linear coding of the variables. |  |  |  |  |
| **5.08c** | c) Understand Pearson's product-moment correlation coefficient as a measure of how close data points lie to a straight line. |  |  |  |  |
| **5.08d** | d) Use and be able to interpret Pearson's product-moment correlation coefficient in hypothesis tests, using either a given critical value or a *p-*value and a table of critical values.*When using Pearson’s coefficient in a hypothesis test, the data may be assumed to come from a bivariate normal distribution.**A table of critical values of Pearson’s coefficient will be provided.* |  |  |  |  |
| **5.08e** | e) Be able to calculate Spearman’s rank correlation coefficient for a maximum of 10 pairs of data values or ranks.*Includes being able to draw basic conclusions about the meaning of a value of the coefficient in relation to the ranks before, or without, carrying out a hypothesis test.**Includes understanding the conditions under which the use of rank correlation may be appropriate.**[Tied ranks are excluded.]* |  |  |  |  |
| **5.08f** | f) Be able to carry out a hypothesis test for association in a population.*Includes understanding that this is a non-parametric test, as it makes no assumptions about the population.**Tables of critical values of Spearman’s coefficient will be provided.* |  |  |  |  |
| **5.08g** | g) Be able to choose between Pearson's product-moment correlation coefficient and Spearman’s rank correlation coefficient for a given context. *Includes interpreting a scatter diagram and distinguishing between linear correlation and association.*  |  |  |  |  |
| **5.09a** | a) Understand the difference between an independent (or controlled) variable and a dependent (or response) variable.*Includes appreciating that, in a given situation, neither parameter may be independent.* |  |  |  |  |
| **5.09b** | b) Understand the concepts of least squares and regression lines in the context of a scatter diagram. |  |  |  |  |
| **5.09c** | c) Be able to calculate, both from raw data and from summarised data, the equation of the regression line of *y* on *x*, where the independent variable (if any) is *x*.[*The regression line of x on y is excluded.*] |  |  |  |  |
| **5.09d** | d) Understand the effect on a regression line of linear coding on one or both variables. |  |  |  |  |
| **5.09e** | e) Be able to use, in the context of a problem, the regression line of *y* on *x* to estimate a value of *y*, and be able to interpret in context the uncertainties of such an estimate. |  |  |  |  |

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