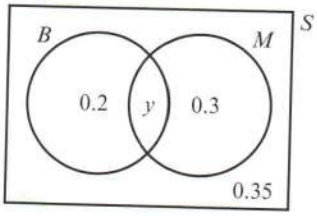
Exam-style practice

Mathematics
AS Level
Paper 2: Statistics and Mechanics

Time: 1 hour 15 minutes
You must have: Mathematical Formulae and Statistical Tables, Calculator

SECTION A: STATISTICS

1 The Venn diagram shows the probabilities that a randomly chosen member of a group of monkeys likes bananas (*B*) or mangoes (*M*).



a Find the value of y. **(1)**

b Determine whether the events 'likes bananas' and 'likes mangoes' are independent. **(2)**

2 Clare is investigating the daily mean temperature in the UK in September 2015. She takes a sample of the first 10 days from September 2015 for Camborne from the large data set. The results are shown below:

14.3 12.8 13.0 13.0 14.3 12.6 13.5 13.7 15.9 17.0

a State, with a reason, whether t is a discrete or continuous variable. **(1)**

Given that $\Sigma t = 140.1$ and $\Sigma t^2 = 1981.33$,

b find the mean and standard deviation of the temperatures. **(3)**

The mean temperature on 11 September is recorded as 15.8 °C.

c State what effect adding this value to the data set would have on the mean temperature. **(1)**

d Suggest how Clare could make better use of the large data set for her study. **(2)**

3 A biased dice has a probability distribution as shown in the table below:

x	1	2	3	4	5	6
$\mathrm{P}(X = x)$	0.1	0.2	0.15	p	0.1	0.25

a Find the value of p. **(1)**

b Find $\mathrm{P}(2 \leqslant X \leqslant 5)$. **(1)**

c The dice is rolled 10 times Find the probability that it lands on an odd number:

i exactly twice **(2)**

ii more than 6 times. **(2)**

4 A factory makes plates using a production line process. On average, 3 out of every 10 plates have flaws. A new production process is introduced designed to make the average number of flaws less. A new sample of 20 plates is taken.

a Describe the test statistic and state suitable null and alternative hypotheses. **(2)**

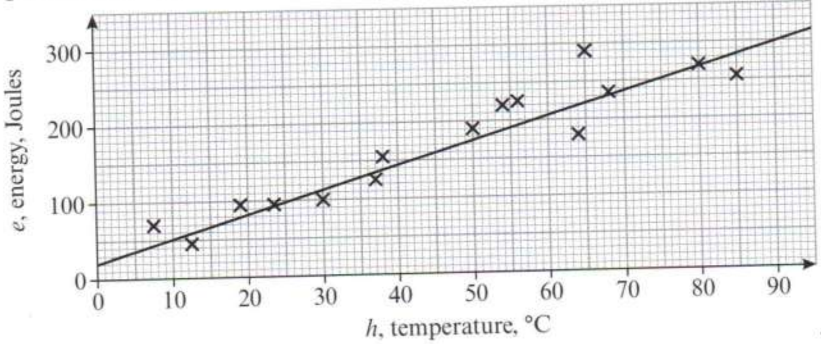
b Using a 5% level of significance, find the critical region for a test to check the belief that the process has improved. **(3)**

c State the actual significance level. **(1)**

In the new sample, only 1 plate has flaws.

d Conclude whether there is evidence that the process has improved. **(1)**

5 A scientist measures the amount of energy released by a chemical reaction, e Joules, against the temperature, h °C.



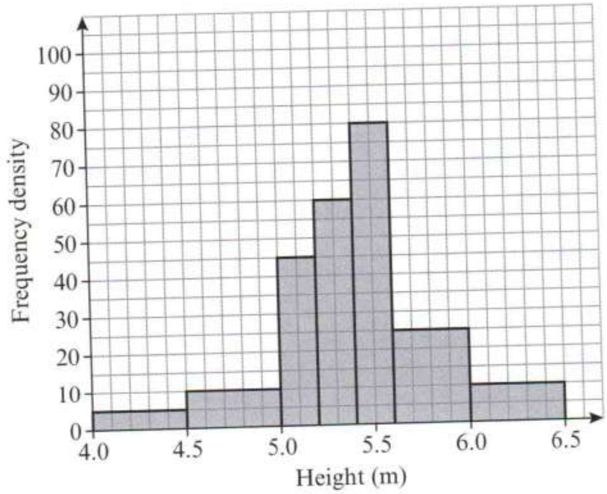
She found the equation of the regression line of e on h to be $e = 20 + 3.1h$.

a Give an interpretation of the value 3.1 in this model. **(1)**

b State, with a reason, whether it is sensible to estimate e when $h = 200$ °C. **(1)**

c State, with a reason, whether it is sensible to measure h when $e = 150$ Joules. **(1)**

6 A conservationist is collecting data on the heights of giraffe. She displays the data in a histogram as shown.



One giraffe is chosen at random. Estimate the probability that it is between 4.6 and 6.1 metres tall. **(4)**

SECTION B: MECHANICS

7 A car is towing a trailer along a straight horizontal road by means of a horizontal tow-rope. The mass of the car is 1500 kg. The mass of the trailer is 700 kg. The car and the trailer are modelled as particles and the tow-rope as a light inextensible string. The resistances to motion of the car and the trailer are assumed to be constant and of magnitude 660 N and 320 N respectively. The driving force on the car, due to its engine, is 2630 N.

Find:

a the acceleration of the car **(3)**

b the tension in the tow-rope. **(3)**

c State how you have used the modelling assumption that the tow-rope is inextensible. **(1)**

8 A particle P of mass 3 kg is moving under the action of forces

$\mathbf{F}_1 = 3\mathbf{i} - 6\mathbf{j}$ N, $\mathbf{F}_2 = 4\mathbf{i} + 5\mathbf{j}$ N and $\mathbf{F}_3 = 2\mathbf{i} - 2\mathbf{j}$ N.

Find:

a the acceleration of P in the form $p\mathbf{i} + q\mathbf{j}$ **(3)**

b angle the acceleration makes with $\mathbf{i}$ **(2)**

c the magnitude of the acceleration. **(2)**

9 A small ball is projected vertically upwards from a point P with speed $u\,\text{m s}^{-1}$. After projection the ball moves freely under gravity until it returns to P. The time between the instant that the ball is projected and the instant that it returns to P is 5 seconds.

The ball is modelled as a particle moving freely under gravity.

Find:

a the value of u **(3)**

b the greatest height above P reached by the ball. **(2)**

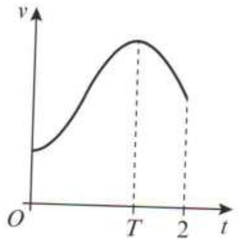
At time t seconds, the ball is 15 m above P.

c Find the possible values of t. **(4)**

10 A particle, P, moves in a straight line through a fixed point O. The velocity of the particle, $v\,\text{m s}^{-1}$ at a time t seconds after passing through O is given by

$v = 3 + 9t^2 - 4t^3,\ 0 \leqslant t \leqslant 2.$

The diagram shows a velocity–time graph of the motion of P.



Find the distance of P from O at time T seconds, when the particle is moving with maximum velocity. **(7)**

Binomial cumulative distribution function

The tabulated value is $P(X \leqslant x)$, where X has a binomial distribution with index n and parameter p.

$p =$	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
$n = 5, x = 0$	0.7738	0.5905	0.4437	0.3277	0.2373	0.1681	0.1160	0.0778	0.0503	0.0312
1	0.9774	0.9185	0.8352	0.7373	0.6328	0.5282	0.4284	0.3370	0.2562	0.1875
2	0.9988	0.9914	0.9734	0.9421	0.8965	0.8369	0.7648	0.6826	0.5931	0.5000
3	1.0000	0.9995	0.9978	0.9933	0.9844	0.9692	0.9460	0.9130	0.8688	0.8125
4	1.0000	1.0000	0.9999	0.9997	0.9990	0.9976	0.9947	0.9898	0.9815	0.9688
$n = 6, x = 0$	0.7351	0.5314	0.3771	0.2621	0.1780	0.1176	0.0754	0.0467	0.0277	0.0156
1	0.9672	0.8857	0.7765	0.6554	0.5339	0.4202	0.3191	0.2333	0.1636	0.1094
2	0.9978	0.9842	0.9527	0.9011	0.8306	0.7443	0.6471	0.5443	0.4415	0.3438
3	0.9999	0.9987	0.9941	0.9830	0.9624	0.9295	0.8826	0.8208	0.7447	0.6563
4	1.0000	0.9999	0.9996	0.9984	0.9954	0.9891	0.9777	0.9590	0.9308	0.8906
5	1.0000	1.0000	1.0000	0.9999	0.9998	0.9993	0.9982	0.9959	0.9917	0.9844
$n = 7, x = 0$	0.6983	0.4783	0.3206	0.2097	0.1335	0.0824	0.0490	0.0280	0.0152	0.0078
1	0.9556	0.8503	0.7166	0.5767	0.4449	0.3294	0.2338	0.1586	0.1024	0.0625
2	0.9962	0.9743	0.9262	0.8520	0.7564	0.6471	0.5323	0.4199	0.3164	0.2266
3	0.9998	0.9973	0.9879	0.9667	0.9294	0.8740	0.8002	0.7102	0.6083	0.5000
4	1.0000	0.9998	0.9988	0.9953	0.9871	0.9712	0.9444	0.9037	0.8471	0.7734
5	1.0000	1.0000	0.9999	0.9996	0.9987	0.9962	0.9910	0.9812	0.9643	0.9375
6	1.0000	1.0000	1.0000	1.0000	0.9999	0.9998	0.9994	0.9984	0.9963	0.9922
$n = 8, x = 0$	0.6634	0.4305	0.2725	0.1678	0.1001	0.0576	0.0319	0.0168	0.0084	0.0039
1	0.9428	0.8131	0.6572	0.5033	0.3671	0.2553	0.1691	0.1064	0.0632	0.0352
2	0.9942	0.9619	0.8948	0.7969	0.6785	0.5518	0.4278	0.3154	0.2201	0.1445
3	0.9996	0.9950	0.9786	0.9437	0.8862	0.8059	0.7064	0.5941	0.4770	0.3633
4	1.0000	0.9996	0.9971	0.9896	0.9727	0.9420	0.8939	0.8263	0.7396	0.6367
5	1.0000	1.0000	0.9998	0.9988	0.9958	0.9887	0.9747	0.9502	0.9115	0.8555
6	1.0000	1.0000	1.0000	0.9999	0.9996	0.9987	0.9964	0.9915	0.9819	0.9648
7	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9998	0.9993	0.9983	0.9961
$n = 9, x = 0$	0.6302	0.3874	0.2316	0.1342	0.0751	0.0404	0.0207	0.0101	0.0046	0.0020
1	0.9288	0.7748	0.5995	0.4362	0.3003	0.1960	0.1211	0.0705	0.0385	0.0195
2	0.9916	0.9470	0.8591	0.7382	0.6007	0.4628	0.3373	0.2318	0.1495	0.0898
3	0.9994	0.9917	0.9661	0.9144	0.8343	0.7297	0.6089	0.4826	0.3614	0.2539
4	1.0000	0.9991	0.9944	0.9804	0.9511	0.9012	0.8283	0.7334	0.6214	0.5000
5	1.0000	0.9999	0.9994	0.9969	0.9900	0.9747	0.9464	0.9006	0.8342	0.7461
6	1.0000	1.0000	1.0000	0.9997	0.9987	0.9957	0.9888	0.9750	0.9502	0.9102
7	1.0000	1.0000	1.0000	1.0000	0.9999	0.9996	0.9986	0.9962	0.9909	0.9805
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9992	0.9980
$n = 10, x = 0$	0.5987	0.3487	0.1969	0.1074	0.0563	0.0282	0.0135	0.0060	0.0025	0.0010
1	0.9139	0.7361	0.5443	0.3758	0.2440	0.1493	0.0860	0.0464	0.0233	0.0107
2	0.9885	0.9298	0.8202	0.6778	0.5256	0.3828	0.2616	0.1673	0.0996	0.0547
3	0.9990	0.9872	0.9500	0.8791	0.7759	0.6496	0.5138	0.3823	0.2660	0.1719
4	0.9999	0.9984	0.9901	0.9672	0.9219	0.8497	0.7515	0.6331	0.5044	0.3770
5	1.0000	0.9999	0.9986	0.9936	0.9803	0.9527	0.9051	0.8338	0.7384	0.6230
6	1.0000	1.0000	0.9999	0.9991	0.9965	0.9894	0.9740	0.9452	0.8980	0.8281
7	1.0000	1.0000	1.0000	0.9999	0.9996	0.9984	0.9952	0.9877	0.9726	0.9453
8	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9995	0.9983	0.9955	0.9893
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9990

$p =$	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
$n = 12, x = 0$	0.5404	0.2824	0.1422	0.0687	0.0317	0.0138	0.0057	0.0022	0.0008	0.0002
1	0.8816	0.6590	0.4435	0.2749	0.1584	0.0850	0.0424	0.0196	0.0083	0.0032
2	0.9804	0.8891	0.7358	0.5583	0.3907	0.2528	0.1513	0.0834	0.0421	0.0193
3	0.9978	0.9744	0.9078	0.7946	0.6488	0.4925	0.3467	0.2253	0.1345	0.0730
4	0.9998	0.9957	0.9761	0.9274	0.8424	0.7237	0.5833	0.4382	0.3044	0.1938
5	1.0000	0.9995	0.9954	0.9806	0.9456	0.8822	0.7873	0.6652	0.5269	0.3872
6	1.0000	0.9999	0.9993	0.9961	0.9857	0.9614	0.9154	0.8418	0.7393	0.6128
7	1.0000	1.0000	0.9999	0.9994	0.9972	0.9905	0.9745	0.9427	0.8883	0.8062
8	1.0000	1.0000	1.0000	0.9999	0.9996	0.9983	0.9944	0.9847	0.9644	0.9270
9	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9992	0.9972	0.9921	0.9807
10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9989	0.9968
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9998
$n = 15, x = 0$	0.4633	0.2059	0.0874	0.0352	0.0134	0.0047	0.0016	0.0005	0.0001	0.0000
1	0.8290	0.5490	0.3186	0.1671	0.0802	0.0353	0.0142	0.0052	0.0017	0.0005
2	0.9638	0.8159	0.6042	0.3980	0.2361	0.1268	0.0617	0.0271	0.0107	0.0037
3	0.9945	0.9444	0.8227	0.6482	0.4613	0.2969	0.1727	0.0905	0.0424	0.0176
4	0.9994	0.9873	0.9383	0.8358	0.6865	0.5155	0.3519	0.2173	0.1204	0.0592
5	0.9999	0.9978	0.9832	0.9389	0.8516	0.7216	0.5643	0.4032	0.2608	0.1509
6	1.0000	0.9997	0.9964	0.9819	0.9434	0.8689	0.7548	0.6098	0.4522	0.3036
7	1.0000	1.0000	0.9994	0.9958	0.9827	0.9500	0.8868	0.7869	0.6535	0.5000
8	1.0000	1.0000	0.9999	0.9992	0.9958	0.9848	0.9578	0.9050	0.8182	0.6964
9	1.0000	1.0000	1.0000	0.9999	0.9992	0.9963	0.9876	0.9662	0.9231	0.8491
10	1.0000	1.0000	1.0000	1.0000	0.9999	0.9993	0.9972	0.9907	0.9745	0.9408
11	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9995	0.9981	0.9937	0.9824
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9997	0.9989	0.9963
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9995
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
$n = 20, x = 0$	0.3585	0.1216	0.0388	0.0115	0.0032	0.0008	0.0002	0.0000	0.0000	0.0000
1	0.7358	0.3917	0.1756	0.0692	0.0243	0.0076	0.0021	0.0005	0.0001	0.0000
2	0.9245	0.6769	0.4049	0.2061	0.0913	0.0355	0.0121	0.0036	0.0009	0.0002
3	0.9841	0.8670	0.6477	0.4114	0.2252	0.1071	0.0444	0.0160	0.0049	0.0013
4	0.9974	0.9568	0.8298	0.6296	0.4148	0.2375	0.1182	0.0510	0.0189	0.0059
5	0.9997	0.9887	0.9327	0.8042	0.6172	0.4164	0.2454	0.1256	0.0553	0.0207
6	1.0000	0.9976	0.9781	0.9133	0.7858	0.6080	0.4166	0.2500	0.1299	0.0577
7	1.0000	0.9996	0.9941	0.9679	0.8982	0.7723	0.6010	0.4159	0.2520	0.1316
8	1.0000	0.9999	0.9987	0.9900	0.9591	0.8867	0.7624	0.5956	0.4143	0.2517
9	1.0000	1.0000	0.9998	0.9974	0.9861	0.9520	0.8782	0.7553	0.5914	0.4119
10	1.0000	1.0000	1.0000	0.9994	0.9961	0.9829	0.9468	0.8725	0.7507	0.5881
11	1.0000	1.0000	1.0000	0.9999	0.9991	0.9949	0.9804	0.9435	0.8692	0.7483
12	1.0000	1.0000	1.0000	1.0000	0.9998	0.9987	0.9940	0.9790	0.9420	0.8684
13	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9985	0.9935	0.9786	0.9423
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9984	0.9936	0.9793
15	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9985	0.9941
16	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9987
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998
18	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

$p =$	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
$n = 25, x = 0$	0.2774	0.0718	0.0172	0.0038	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000
1	0.6424	0.2712	0.0931	0.0274	0.0070	0.0016	0.0003	0.0001	0.0000	0.0000
2	0.8729	0.5371	0.2537	0.0982	0.0321	0.0090	0.0021	0.0004	0.0001	0.0000
3	0.9659	0.7636	0.4711	0.2340	0.0962	0.0332	0.0097	0.0024	0.0005	0.0001
4	0.9928	0.9020	0.6821	0.4207	0.2137	0.0905	0.0320	0.0095	0.0023	0.0005
5	0.9988	0.9666	0.8385	0.6167	0.3783	0.1935	0.0826	0.0294	0.0086	0.0020
6	0.9998	0.9905	0.9305	0.7800	0.5611	0.3407	0.1734	0.0736	0.0258	0.0073
7	1.0000	0.9977	0.9745	0.8909	0.7265	0.5118	0.3061	0.1536	0.0639	0.0216
8	1.0000	0.9995	0.9920	0.9532	0.8506	0.6769	0.4668	0.2735	0.1340	0.0539
9	1.0000	0.9999	0.9979	0.9827	0.9287	0.8106	0.6303	0.4246	0.2424	0.1148
10	1.0000	1.0000	0.9995	0.9944	0.9703	0.9022	0.7712	0.5858	0.3843	0.2122
11	1.0000	1.0000	0.9999	0.9985	0.9893	0.9558	0.8746	0.7323	0.5426	0.3450
12	1.0000	1.0000	1.0000	0.9996	0.9966	0.9825	0.9396	0.8462	0.6937	0.5000
13	1.0000	1.0000	1.0000	0.9999	0.9991	0.9940	0.9745	0.9222	0.8173	0.6550
14	1.0000	1.0000	1.0000	1.0000	0.9998	0.9982	0.9907	0.9656	0.9040	0.7878
15	1.0000	1.0000	1.0000	1.0000	1.0000	0.9995	0.9971	0.9868	0.9560	0.8852
16	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9992	0.9957	0.9826	0.9461
17	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9988	0.9942	0.9784
18	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9984	0.9927
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9996	0.9980
20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9995
21	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
$n = 30, x = 0$	0.2146	0.0424	0.0076	0.0012	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.5535	0.1837	0.0480	0.0105	0.0020	0.0003	0.0000	0.0000	0.0000	0.0000
2	0.8122	0.4114	0.1514	0.0442	0.0106	0.0021	0.0003	0.0000	0.0000	0.0000
3	0.9392	0.6474	0.3217	0.1227	0.0374	0.0093	0.0019	0.0003	0.0000	0.0000
4	0.9844	0.8245	0.5245	0.2552	0.0979	0.0302	0.0075	0.0015	0.0002	0.0000
5	0.9967	0.9268	0.7106	0.4275	0.2026	0.0766	0.0233	0.0057	0.0011	0.0002
6	0.9994	0.9742	0.8474	0.6070	0.3481	0.1595	0.0586	0.0172	0.0040	0.0007
7	0.9999	0.9922	0.9302	0.7608	0.5143	0.2814	0.1238	0.0435	0.0121	0.0026
8	1.0000	0.9980	0.9722	0.8713	0.6736	0.4315	0.2247	0.0940	0.0312	0.0081
9	1.0000	0.9995	0.9903	0.9389	0.8034	0.5888	0.3575	0.1763	0.0694	0.0214
10	1.0000	0.9999	0.9971	0.9744	0.8943	0.7304	0.5078	0.2915	0.1350	0.0494
11	1.0000	1.0000	0.9992	0.9905	0.9493	0.8407	0.6548	0.4311	0.2327	0.1002
12	1.0000	1.0000	0.9998	0.9969	0.9784	0.9155	0.7802	0.5785	0.3592	0.1808
13	1.0000	1.0000	1.0000	0.9991	0.9918	0.9599	0.8737	0.7145	0.5025	0.2923
14	1.0000	1.0000	1.0000	0.9998	0.9973	0.9831	0.9348	0.8246	0.6448	0.4278
15	1.0000	1.0000	1.0000	0.9999	0.9992	0.9936	0.9699	0.9029	0.7691	0.5722
16	1.0000	1.0000	1.0000	1.0000	0.9998	0.9979	0.9876	0.9519	0.8644	0.7077
17	1.0000	1.0000	1.0000	1.0000	0.9999	0.9994	0.9955	0.9788	0.9286	0.8192
18	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9986	0.9917	0.9666	0.8998
19	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9996	0.9971	0.9862	0.9506
20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9991	0.9950	0.9786
21	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9984	0.9919
22	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9996	0.9974
23	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9993
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

$p =$	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
$n = 40, x = 0$	0.1285	0.0148	0.0015	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.3991	0.0805	0.0121	0.0015	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.6767	0.2228	0.0486	0.0079	0.0010	0.0001	0.0000	0.0000	0.0000	0.0000
3	0.8619	0.4231	0.1302	0.0285	0.0047	0.0006	0.0001	0.0000	0.0000	0.0000
4	0.9520	0.6290	0.2633	0.0759	0.0160	0.0026	0.0003	0.0000	0.0000	0.0000
5	0.9861	0.7937	0.4325	0.1613	0.0433	0.0086	0.0013	0.0001	0.0000	0.0000
6	0.9966	0.9005	0.6067	0.2859	0.0962	0.0238	0.0044	0.0006	0.0001	0.0000
7	0.9993	0.9581	0.7559	0.4371	0.1820	0.0553	0.0124	0.0021	0.0002	0.0000
8	0.9999	0.9845	0.8646	0.5931	0.2998	0.1110	0.0303	0.0061	0.0009	0.0001
9	1.0000	0.9949	0.9328	0.7318	0.4395	0.1959	0.0644	0.0156	0.0027	0.0003
10	1.0000	0.9985	0.9701	0.8392	0.5839	0.3087	0.1215	0.0352	0.0074	0.0011
11	1.0000	0.9996	0.9880	0.9125	0.7151	0.4406	0.2053	0.0709	0.0179	0.0032
12	1.0000	0.9999	0.9957	0.9568	0.8209	0.5772	0.3143	0.1285	0.0386	0.0083
13	1.0000	1.0000	0.9986	0.9806	0.8968	0.7032	0.4408	0.2112	0.0751	0.0192
14	1.0000	1.0000	0.9996	0.9921	0.9456	0.8074	0.5721	0.3174	0.1326	0.0403
15	1.0000	1.0000	0.9999	0.9971	0.9738	0.8849	0.6946	0.4402	0.2142	0.0769
16	1.0000	1.0000	1.0000	0.9990	0.9884	0.9367	0.7978	0.5681	0.3185	0.1341
17	1.0000	1.0000	1.0000	0.9997	0.9953	0.9680	0.8761	0.6885	0.4391	0.2148
18	1.0000	1.0000	1.0000	0.9999	0.9983	0.9852	0.9301	0.7911	0.5651	0.3179
19	1.0000	1.0000	1.0000	1.0000	0.9994	0.9937	0.9637	0.8702	0.6844	0.4373
20	1.0000	1.0000	1.0000	1.0000	0.9998	0.9976	0.9827	0.9256	0.7870	0.5627
21	1.0000	1.0000	1.0000	1.0000	1.0000	0.9991	0.9925	0.9608	0.8669	0.6821
22	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9970	0.9811	0.9233	0.7852
23	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9989	0.9917	0.9595	0.8659
24	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9996	0.9966	0.9804	0.9231
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9988	0.9914	0.9597
26	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9996	0.9966	0.9808
27	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9988	0.9917
28	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9996	0.9968
29	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9989
30	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997
31	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999
32	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

$p =$	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
$n = 50, x = 0$	0.0769	0.0052	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.2794	0.0338	0.0029	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.5405	0.1117	0.0142	0.0013	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.7604	0.2503	0.0460	0.0057	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.8964	0.4312	0.1121	0.0185	0.0021	0.0002	0.0000	0.0000	0.0000	0.0000
5	0.9622	0.6161	0.2194	0.0480	0.0070	0.0007	0.0001	0.0000	0.0000	0.0000
6	0.9882	0.7702	0.3613	0.1034	0.0194	0.0025	0.0002	0.0000	0.0000	0.0000
7	0.9968	0.8779	0.5188	0.1904	0.0453	0.0073	0.0008	0.0001	0.0000	0.0000
8	0.9992	0.9421	0.6681	0.3073	0.0916	0.0183	0.0025	0.0002	0.0000	0.0000
9	0.9998	0.9755	0.7911	0.4437	0.1637	0.0402	0.0067	0.0008	0.0001	0.0000
10	1.0000	0.9906	0.8801	0.5836	0.2622	0.0789	0.0160	0.0022	0.0002	0.0000
11	1.0000	0.9968	0.9372	0.7107	0.3816	0.1390	0.0342	0.0057	0.0006	0.0000
12	1.0000	0.9990	0.9699	0.8139	0.5110	0.2229	0.0661	0.0133	0.0018	0.0002
13	1.0000	0.9997	0.9868	0.8894	0.6370	0.3279	0.1163	0.0280	0.0045	0.0005
14	1.0000	0.9999	0.9947	0.9393	0.7481	0.4468	0.1878	0.0540	0.0104	0.0013
15	1.0000	1.0000	0.9981	0.9692	0.8369	0.5692	0.2801	0.0955	0.0220	0.0033
16	1.0000	1.0000	0.9993	0.9856	0.9017	0.6839	0.3889	0.1561	0.0427	0.0077
17	1.0000	1.0000	0.9998	0.9937	0.9449	0.7822	0.5060	0.2369	0.0765	0.0164
18	1.0000	1.0000	0.9999	0.9975	0.9713	0.8594	0.6216	0.3356	0.1273	0.0325
19	1.0000	1.0000	1.0000	0.9991	0.9861	0.9152	0.7264	0.4465	0.1974	0.0595
20	1.0000	1.0000	1.0000	0.9997	0.9937	0.9522	0.8139	0.5610	0.2862	0.1013
21	1.0000	1.0000	1.0000	0.9999	0.9974	0.9749	0.8813	0.6701	0.3900	0.1611
22	1.0000	1.0000	1.0000	1.0000	0.9990	0.9877	0.9290	0.7660	0.5019	0.2399
23	1.0000	1.0000	1.0000	1.0000	0.9996	0.9944	0.9604	0.8438	0.6134	0.3359
24	1.0000	1.0000	1.0000	1.0000	0.9999	0.9976	0.9793	0.9022	0.7160	0.4439
25	1.0000	1.0000	1.0000	1.0000	1.0000	0.9991	0.9900	0.9427	0.8034	0.5561
26	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9955	0.9686	0.8721	0.6641
27	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9981	0.9840	0.9220	0.7601
28	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9993	0.9924	0.9556	0.8389
29	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9966	0.9765	0.8987
30	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9986	0.9884	0.9405
31	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9995	0.9947	0.9675
32	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998	0.9978	0.9836
33	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9991	0.9923
34	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9997	0.9967
35	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9987
36	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9995
37	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9998
38	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Answers

Prior knowledge 1

1 a Mean 5.89 (2 d.p.); Median 6; Mode 4; Range 10
b Mean 18.38 (2 d.p.); Median 18.5; Mode 20; Range 9
2 ANY TWO FROM: Overlapping categories; No option for > 4 hours; Question doesn't specify a period of time.
How much TV do you watch each day?
0–1 hours 2–3 hours 4 hours or more
3 a 29 b 35 c 38 d 95

Exercise 1A

1 a A census observes or measures every member of a population.
b Advantage: will give a completely accurate result. Disadvantage: ANY ONE FROM: time consuming, expensive.
2 a The testing process will destroy the harness, so a census would destroy *all* the harnesses.
b 250 kg is the median load at which the harnesses in the sample break. This means that half of the harnesses will break at a load less than 250 kg.
c Test a larger number of harnesses.
3 a ANY ONE FROM:
It would be expensive.
It would be time consuming.
It would be difficult.
b A list of residents. c A resident.
4 a The testing process will destroy the microswitches, so a census would destroy *all* the switches.
b The mean is less than the stated average but one of the switches lasted a significantly lower number of operations which suggests the median might be a better average to take – not affected by outliers. The data supports the company claim.
c Test a larger number of microswitches.
5 a All the mechanics in the garage.
b Everyone's views will be known.

Exercise 1B

1 a Year 1: 8, Year 2: 12, Year 3: 16
b ANY ONE FROM: sample accurately reflects the population structure of the school; guarantees proportional representation of different year groups in the sample.
2 a Patterns in the sample data might occur when taking every 20th person.
b A simple random sample using the alphabetical list as the sampling frame.
3 a No: A systematic sample requires the first selected person to be chosen at random.
b Take a simple random sample using the list of members as the sampling frame.
4 a Stratified sampling.
b Male Y12: 10, Male Y13: 7, Female Y12: 12, Female Y13: 11
5 $k = \frac{480}{30} = 16$
Randomly select a number between 1 and 16. Starting with the worker with this clocking-in number, select the workers that have every 16th clocking-in number after this.
6 a Any method in which every member of the population has an equal chance of being selected, e.g. lottery. Disadvantage: the sample may not accurately reflect the proportions of members at the club who play each sport.
b The sample will have proportional representation of the members who play the different sports.
c Cricket: 10, Hockey: 12, Squash: 8

Exercise 1C

1 a i Divide the population into groups according to given characteristics. The size of each group determines the proportion of the sample that should have that characteristic. The interviewer assesses which group people fall into as part of the interview. Once a quota has been filled, no more people in that group are interviewed.
ii Opportunity sampling consists of taking the sample from the people who are available at the time the study is carried out, e.g. the first 40 shoppers who are available to be interviewed.
b Quota sampling.
2 Similarities: The population is divided according to the characteristics of the whole population (into strata for stratified sampling, and groups for quota sampling)
Differences: Stratified sampling uses random sampling whereas quota sampling does not.
3 a Opportunity sampling
b Sample is likely to be biased towards people who eat fish and chips on a Friday.
c Survey people at different times of day. Survey people in other parts of the town, not outside the fish and chip shop.
4 a 5.4 hours
b Opportunity sampling; unlikely to provide a representative sample of the town as a whole
c Increase the number of people asked. Ask people at different times/in different locations.
5 a Quota sampling.
b ANY ONE FROM: no sampling frame required, quick, easy, inexpensive, allows for comparison between male and female deer.
c Males are on average heavier and have a greater spread.
d Increase the sample size. Catch deer at random times during the day.
6 a Student's opportunity sample: For example, first five values
b 1.9, 2.0, 2.6, 2.3, 2.0
c 1.96 m, 2.16 m
d Systematic sample – is random and likely to be more representative. Opportunity sample might get all the small values, for example.

Exercise 1D

1 a Quantitative b Qualitative
c Quantitative d Quantitative
e Qualitative
2 a Discrete b Continuous
c Discrete d Continuous
e Continuous f Continuous
3 a It is descriptive rather than numerical.
b It is quantitative because it is numerical. It is discrete because its value must be an integer; you cannot have fractions of a pupil.
c It is quantitative because it is numerical. It is continuous because weight can take any value in a given range.

4 a 1.4 kg and 1.5 kg b 1.35 kg
c 0.1 kg

Exercise 1E

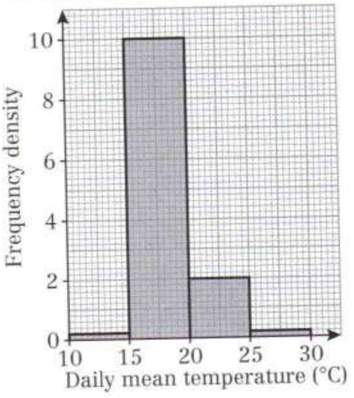
1 a Leuchars
b Perth
c ANY ONE FROM: Leeming, Heathrow, Beijing
d ANY ONE FROM: Leuchars, Hurn, Camborne, Jacksonville, Perth
e ANY ONE FROM: Beijing, Jacksonville, Perth
2 Continuous – it can take any value in the range 0 to 100
3 a i 10.14 hours ii 7.6 hours
b i 9.5 hours ii 12.8 hours
c The mean of the daily total sunshine in Leeming is higher than that in Heathrow. Leeming is north of Heathrow, so these data do not support Supraj's conclusion.
4 0.14 mm, treat tr. as 0 in numerical calculations.
5 a i Covers several months ii Small sample size
b Two consecutive days chosen all the time – not random, possibly have similar weather.
c Number the days and choose a simple random sample.
6 a Perth is in the southern hemisphere so August is a winter month
b The lowest temperatures in the UK are at coastal locations (Camborne and Leuchars). The highest temperature is at an inland location (Beijing). There is some evidence to support this conclusion.
7 Oktas measure the cloud coverage in eighths. The highest value is 8 which represents full cloud coverage.
8 a She needs to select days at regular intervals in an ordered list. Put the days into date order. Select every sixth day ($184 \div 30 = 6.13$).
b Some of the data values might not be available (n/a).

Large data set

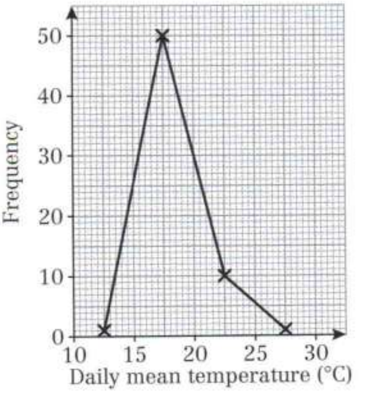
1 a 1020 hPa
b 0.0 mm
c i

Temperature, t (°C)	Frequency
$10 \leqslant t < 15$	1
$15 \leqslant t < 20$	50
$20 \leqslant t < 25$	10
$25 \leqslant t < 30$	1

ii



iii



2 Students' own answer.

Mixed exercise 1

1 a 9.6°C
b Sampling frame: first 15 days in May 1987
Allocate each date a number from 1 to 15
Use the random number function on calculator to generate 5 numbers between 1 and 15
c Students' own answers.
d 10.8°C
2 a i Advantage: very accurate; disadvantage: expensive (time consuming).
ii Advantage: easier data collection (quick, cheap); disadvantage: possible bias.
b Assign unique 3-digit identifiers 000, 001, ..., 499 to each member of the population. Work along rows of random number tables generating 3-digit numbers. If these correspond to an identifier then include the corresponding member in the sample; ignore repeats and numbers greater than 499. Repeat this process until the sample contains 100 members.
3 a i Collection of individual items.
ii List of sampling units.
b i List of registered owners from DVLA.
ii List of people visiting a doctor's clinic in Oxford in July 1996.
4 a Advantage – the results are the most representative of the population since the structure of the sample reflects the structure of the population.
Disadvantage – you need to know the structure of the population before you can take a stratified sample.
b Advantage – quick and cheap.
Disadvantage – can introduce bias (e.g. if the sample, by chance, only includes very tall people in an investigation into heights of students).
5 a People not in office not represented.
b i Get a list of the 300 workers at the factory.
$\frac{300}{30} = 10$ so choose one of the first ten workers on the list at random and every subsequent 10th worker on the list, e.g. if person 7 is chosen, then the sample includes workers 7, 17, 27, ..., 297.
ii The population contains 100 office workers ($\frac{1}{3}$ of population) and 200 shop floor workers ($\frac{2}{3}$ of population).
The sample should contain $\frac{1}{3} \times 30 = 10$ office workers and $\frac{2}{3} \times 30 = 20$ shop floor workers.
The 10 office workers in the sample should be a simple random sample of the 100 office workers.
The 20 shop floor workers should be a simple random sample of the 200 shop floor workers.

iii Decide the categories e.g. age, gender, office/non office and set a quota for each in proportion to their numbers in the population. Interview workers until quotas are full.

6 a Allocate a number between 1 and 120 to each pupil. Use random number tables, computer or calculator to select 15 different numbers between 1 and 120 (or equivalent).
Pupils corresponding to these numbers become the sample.

b Allocate numbers 1–64 to girls and 65–120 to boys. Select $\frac{64}{120} \times 15 = 8$ different random numbers between 1 and 64 for girls.
Select 7 different random numbers between 65 and 120 for boys. Include the corresponding boys and girls in the sample.

7 a Stratified sampling.
b Uses naturally occurring (strata) groupings. The results are more likely to represent the views of the population since the sample reflects its structure.

8 a Opportunity sampling.
b ANY ONE FROM: Easy to carry out, Inexpensive.
c Continuous – weight can take any value.
d 76 kg
e 79.6 kg
f The second conservationist is likely to have a more reliable estimate as opportunity sampling is unlikely to provide a representative sample.
g Select more springboks at each location.

9 a This sample is not entirely random as the dates are selected at regular intervals. It is actually a systematic sample.
b Select the first date at random and then the same date each month – systematic sample. Advantage: each month covered; Disadvantage: may be patterns in the sample data. Select the six days at random – simple random sample. Advantage: avoids likelihood of patterns; Disadvantage: May not cover the full range of months.
c Continuous – rainfall can take any value.
d 8.2 mm
e This estimate is unlikely to be reliable as it does not include the winter months.

Large data set
a Student's own answer.
b Simple and quick to use.
c Student's own answer.
d The sampling frame is not random (it is in date order) so systematic sampling could introduce bias. Could improve the estimate by using a random sample.

CHAPTER 2

Prior knowledge 2

1 a Qualitative **b** Quantitative
c Qualitative **d** Quantitative
2 a Discrete **b** Continuous
c Continuous **d** Discrete
e Continuous
3 Mean: 5.33, Median: 6, Mode: 6, Range: 4

Exercise 2A

1 a 700 g **b** 600 g **c** 700 g
d The mean will increase; the mode will remain unchanged; the median will decrease.
2 a 42.7
b The mean will increase.
3 a May: 23 355 m, June: 21 067 m
b 22 230 m
4 a 8 minutes **b** 10.2 minutes **c** 8.5 minutes
d The median would be best. The mean is affected by the extreme value 26.
5 a 2 **b** 1 **c** 1.47 **d** the median
6 6.31 petals
7 1

Exercise 2B

1 a £351 to £400 **b** £345 **c** £351 to £400
2 a 82.3 decibels
b The mean is an estimate as we don't know the exact noise levels recorded.
3 a $10 \leqslant t < 12$
b 11.4 °C
4 Store B (mean 52 years) employs older workers than store A (mean 50 years).

Exercise 2C

1 a 1020 hPa **b** $Q_1 = 1017$ hPa, $Q_3 = 1024.5$ hPa
2 Median 37, $Q_1 = 37$, $Q_3 = 38$
3 1.08
4 a 432 kg **b** 389 kg **c** 480 kg
d Three-quarters of the cows weigh 480 kg or less.
5 a 44.0 minutes **b** 48.8 minutes
c 90th percentile = 57.8 minutes so 10% of customers have to wait longer than 57.8 minutes, not 56 minutes as stated by the firm.
6 a 2.84 m. 80% of condors have a wingspan of less than 2.84 m.
b The 90th percentile is in the $3.0 \leqslant w$ class. There is no upper boundary for this class, so it is not possible to estimate the 90th percentile.

Exercise 2D

1 a 71 **b** 24.6 **c** 193.1 mm **d** 8
2 a £81.90 **b** 22
3 a 6.2 minutes **b** 54
4 a Median 11.5 °C, $Q_1 = 10.3$ °C, $Q_3 = 12.7$ °C, IQR = 2.4 °C
b On average, the temperature was higher in June than in May (higher median). The temperature was more variable in May than June (higher IQR).
c 24 days

Exercise 2E

1 a 3 **b** 0.75 **c** 0.866
2 3.11 kg
3 a 178 cm **b** 59.9 cm² **c** 7.74 cm
4 Mean 5.44, standard deviation 2.35
5 a Mean £10.22, standard deviation £1.35
b 19
6 1.23 days
7 Mean 16.1 hours, standard deviation 4.69 hours
One standard deviation below mean 11.41 hours.
41 parts tested (82%) lasted longer than one standard deviation below the mean. According to the manufacturers, this should be 45 parts (90%), so the claim is false.
8 a Mean 8.1 kn, standard deviation 3.41 kn
b 13 days
c The windspeeds are equally distributed throughout the range.

Exercise 2F

1 a 11, 9, 5, 8, 3, 7, 6 b 7 c 70
2 a 7, 10, 4, 10, 5, 11, 2, 3 b 6.5 c 48.5
3 365
4 2.34
5 a 1.2 hours b 25.1 hours c 1.76 hours
6 22.9
7 416 mm
8 a $t = 0.8(m + 12)$ or $t = \frac{m + 12}{1.25}$
b Mean 54, standard deviation 0.64
9 Mean 1020 hPa, standard deviation 6.29 hPa

Mixed exercise 2

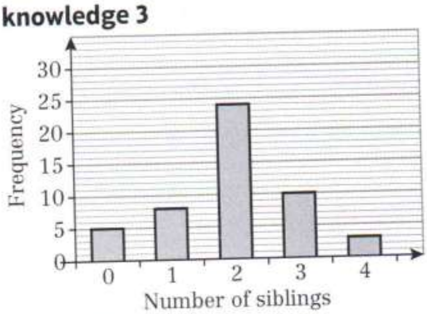
1 69.2
2 a 10, 12, 9, 2, 2.5, 9.5 b 7.5 c 607
3 £18 720
4 a Group A 63.4, group B 60.2
b The method used for group A may be better.
5 a 21 to 25 hours b 21.6 hours
c 20.6 hours d 20.8 hours
6 37.5
7 a 20.5 b 34.7 c 14.2
8 a 13.1
b Variance 102, standard deviation 10.1 minutes
9 a 98.75 mm b 104 mm c 5.58 mm d 4.47 mm
10 a Mean 13.5, standard deviation 1.36
b 4.0 °C c 5 days
11 a Mean 3.42, standard deviation 1.61
b Mean 9.84 knots, standard deviation 3.22 knots
12 a Mean 15.8 cm, standard deviation 2.06 cm
b The mean wingspan will decrease.
c Mean 57 cm, standard deviation 3 cm

Challenge
Mean 3.145 cm, standard deviation 1.39 cm

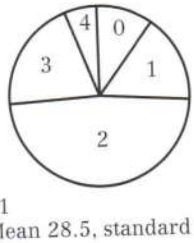
CHAPTER 3

Prior knowledge 3

1 a



b



2 11
3 Mean 28.5, standard deviation 7.02

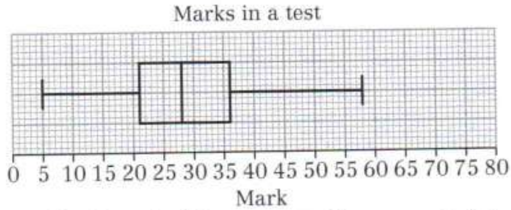
Exercise 3A

1 a 7 is an outlier b 88 is not an outlier
c 105 is an outlier
2 a No outliers b 170 g and 440 g
c 760 g

3 a 11.5 kg
b Smallest 2.0 kg, largest 10.2 kg
4 a Mean 10.2, standard deviation 7.36
b It is an outlier as it is more than 2 standard deviations above the mean.
c e.g. It could be the age of a parent at the party.
d Mean 7.75, standard deviation 2.44

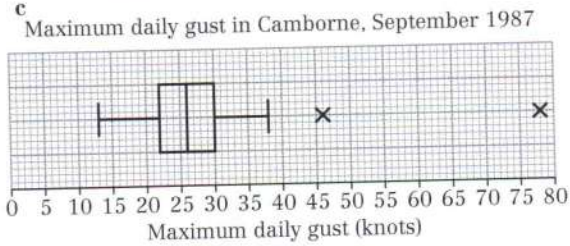
Exercise 3B

1



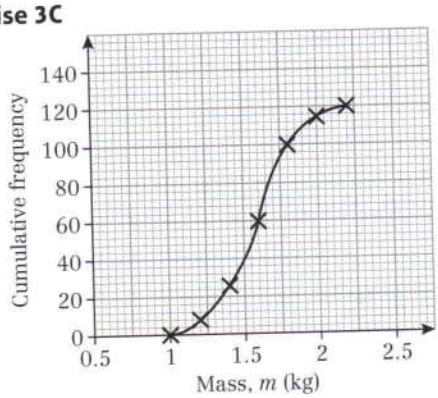
2 a 47, 32 b 38 c 15 d 64
3 a The male turtles have a higher median mass, a greater interquartile range and a greater total range.
b It is more likely to have been female. Very few of the male turtles had a mass this low, but more than a quarter of the female turtles had a mass of more than this.
c 500 g
4 a $Q_1 = 22$ knots, Q_2 26 knots, $Q_3 = 30$ knots
b IQR = 8
$1.5 \times$ IQR above $Q_3 = 42$
$46 > 42$ and $78 > 42$, so 46 and 78 are outliers.

c



Exercise 3C

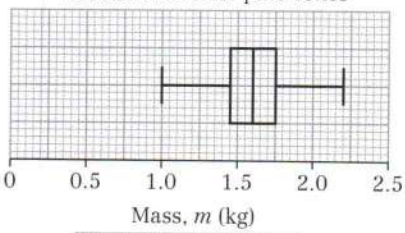
1 a



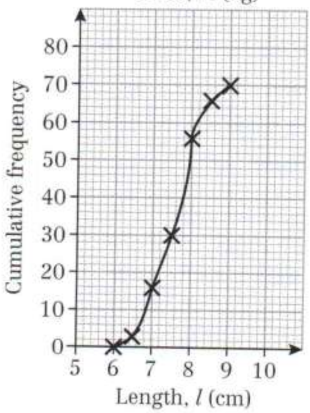
b ≈ 1.6 kg
c IQR ≈ 0.3, 10th to 90th interpercentile range ≈ 0.65

Online Full worked solutions are available in SolutionBank.

d Masses of Coulter pine cones



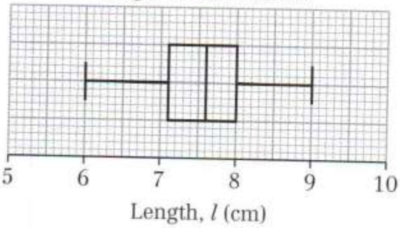
2 a



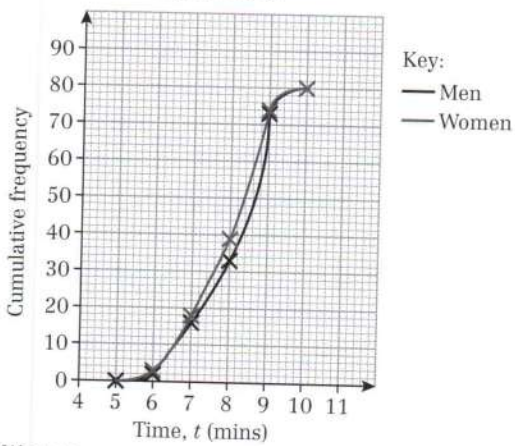
b Median ≈ 7.6, $Q_1 \approx 7.1$, $Q_3 \approx 8$

c **i** ≈ 8 **ii** ≈ 24

d Length of earthworms



3 a

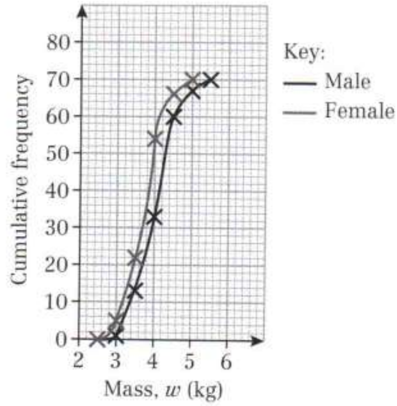


b Women

c Men

d Men ≈ 24, women ≈ 28

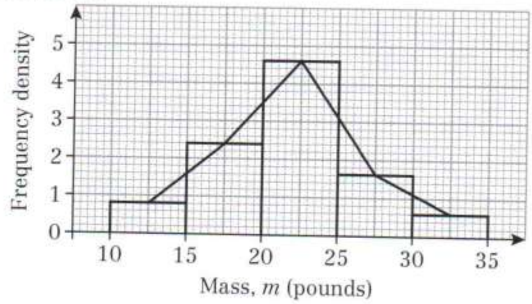
4 a



b Male **c** Female

Exercise 3D

1



2 a The quantity (time) is continuous.

b 150 **c** 369 **d** 699

3 a The quantity (distance) is continuous.

b 310 **c** 75 **d** 95 **e** 65

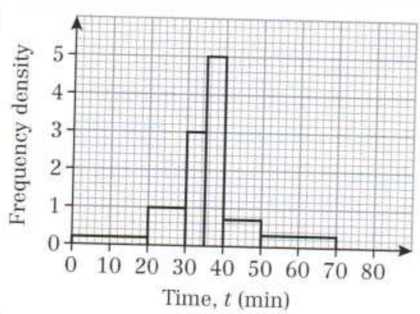
4 a 32 lambs is represented by 100 small squares, therefore 25 small squares represents 8 lambs.

b 32 **c** 168 **d** 88

5 a i

Time, *t* (min)	Frequency
$0 \leqslant t < 20$	4
$20 \leqslant t < 30$	10
$30 \leqslant t < 35$	15
$35 \leqslant t < 40$	25
$40 \leqslant t < 50$	7
$50 \leqslant t < 70$	6

ii



b 35

6 a 12.5 and 14.5

b **i** 6 cm **ii** 3 cm

7 a Width 0.5 cm, height 14 cm

b Mean 10.4, standard deviation 2.4

c 9 °C **d** 4.7 days

Exercise 3E

1 The median speed is higher on motorway A than on motorway B. The spread of speeds for motorway B is greater than the spread of speeds for motorway A (comparing IQRs).

2 Class 2B: mean 32.5, standard deviation 6.6
Class 2F: mean 27.2, standard deviation 11.4
The mean time for Class 2B is higher than the mean time for Class 2F. The standard deviation for Class 2F is bigger than for Class 2B, showing that the times were more spread out.

3 The median height for boys (163 cm) is higher than the median height for girls (158 cm). The spread of heights for boys is greater than the spread of heights for girls (comparing IQRs).

4 **a** Leuchars: median 100, $Q_1 = 98$, $Q_3 = 100$
Camborne: median 98, $Q_1 = 92$, $Q_3 = 100$
b The median humidity in Leuchars is higher than the median humidity in Camborne. The spread of humidities for Camborne is greater than the spread of humidities for Leuchars.

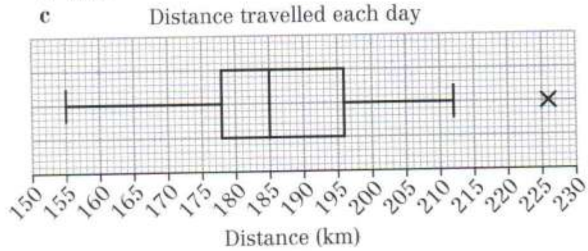
Large data set

1 **a** 1987: 6.6 kn, 2015: 7.7 kn
b 1987: 4 kn, 2015: 7 kn
c 1987: 3.0 kn, 2015: 2.8 kn

2 The mean windspeeds were higher in 2015 than in 1987. The spread of the speeds was greater in 1987 than in 2015 (higher standard deviation).

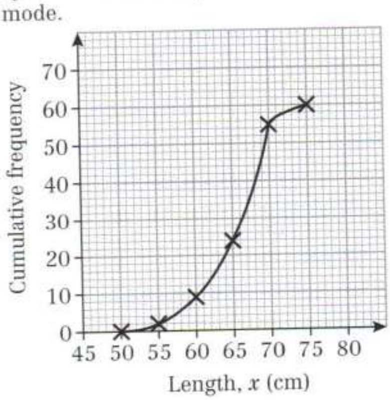
Mixed exercise 3

1 **a** $Q_1 = 178$, $Q_2 = 185$, $Q_3 = 196$
b 226
c Distance travelled each day



2 **a** 45 minutes **b** 60 minutes
c This represents an outlier.
d Irt has a higher median than Esk.
The interquartile ranges were about the same.
e Esk had the fastest runners.
f Advantages: easy to compare quartiles, median and spread. Disadvantages: cannot compare mean or mode.

3 **a**

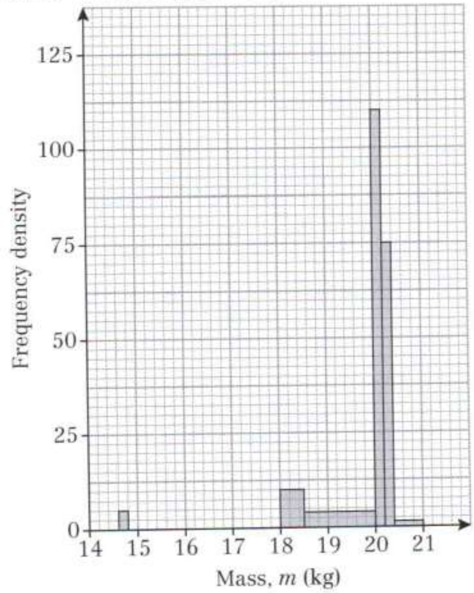


b ≈ 66 cm
c ≈ 6.5 cm
d The distributions have very similar medians and quartiles. Maximum length of the European badgers is greater than the maximum length of the honey badgers.
e Do not have exact data values so cannot compare the median, quartiles or range accurately.

4 **a** 26
b 17

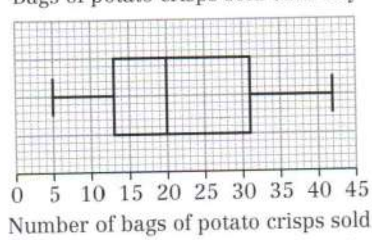
5 **a** width = 1.5 cm, height = 2.6 cm
b width = 7.5 cm, height = 0.28 cm

6 **a**



b Mean 19.8 kg, standard deviation 0.963 kg
c 20.1 kg

7 **a** 22.3
b Median 20; quartiles 13, 31
c No outliers.
d Bags of potato crisps sold each day



8 **a** The maximum gust is continuous data and the data is given in a grouped frequency table.
b 1 cm wide and 13.5 cm tall
c Mean 23.4, standard deviation 7.32
d 44 days

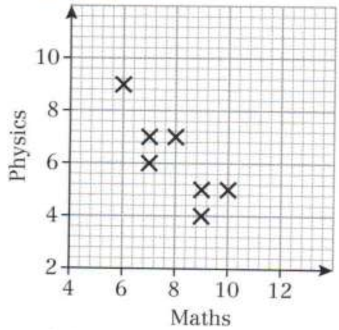
9 **a** 1987: 11.9 °C, 2015: 12.1 °C
b The mean temperature was slightly higher in 2015 than in 1987. The standard deviation of temperatures was higher in 1987 (2.46 °C) than in 2015 showing that the temperatures were more spread out.
c 15 days assuming that the temperatures are equally distributed throughout the range.

Challenge:
0.6 cm

CHAPTER 4

Prior knowledge 4

1



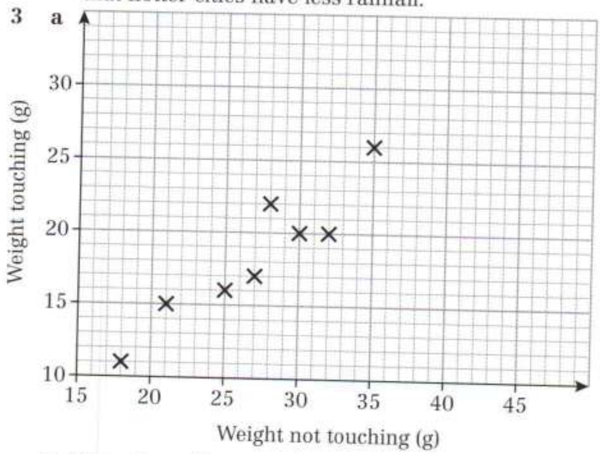
2 **a** −3.21
b 0.34

Exercise 4A

1 **a** Positive correlation.
b The longer the treatment, the greater the loss of weight.

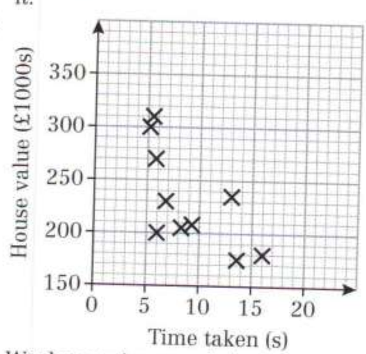
2 **a** No correlation.
b The scatter graph does not support the statement that hotter cities have less rainfall.

3 **a**



b There is positive correlation. If a student guessed a greater weight before touching the bag, they were more likely to guess a greater weight after touching it.

4 **a**

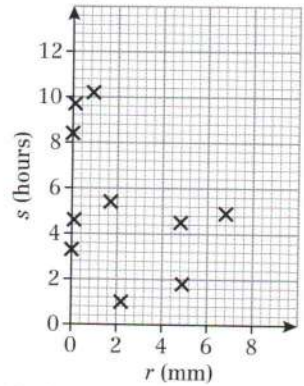


b Weak negative correlation.
c For example, there may be a third variable that influences both house value and internet connection, such as distance from built up areas.

5 **a** $Q_3 + 1.5 \times \text{IQR} = 4.85 + 7.125 = 11.975$
$21.7 > 11.975$, therefore is an outlier.

b **i** There is no reason to believe that the data collected by the Met Office is incorrect.
ii 21.7 is an outlier so may not be representative of the typical rainfall.

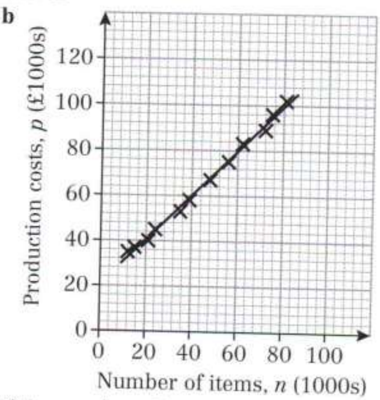
c



d Weak negative correlation.
e For example, there could be a causal relationship as days with more rainfall will have more clouds, and therefore less sunshine.

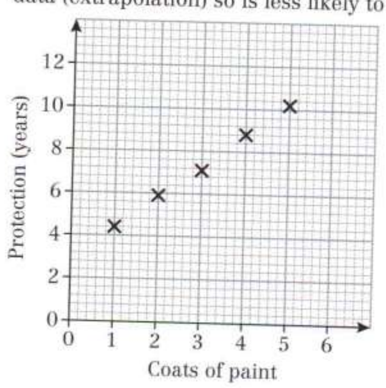
Exercise 4B

1 **a, b**



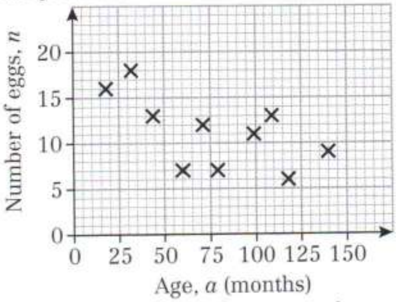
c If the number of items produced per month is zero, the production costs will be approximately £21 000. If the number of items per month increases by 1000 items, the production costs increase by approximately £980.
d The prediction for 74 000 is within the range of the data (interpolation) so is more likely to be accurate. The prediction for 95 000 is outside the range of the data (extrapolation) so is less likely to be accurate.

2 **a**



b A gradient of 1.45 means that for every extra coat of paint, the protection will increase by 1.45 years, therefore if 10 coats of paint are applied, the protection will be 14.5 years longer than if zero coats of paint were applied. After 10 coats of paint, the protection will last 2.93 + 14.5 = 17.43 years.

3 a



b The scatter diagram shows negative correlation, therefore the gradient in the regression equation should be negative.

4 This is not sensible as there are unlikely to be any houses with no bedrooms.

5 a For each percent increase in daily maximum relative humidity there is a decrease of 106 Dm in daily mean visibility.

b High levels of relative humidity cause mist or fog which will decrease visibility. Hence there is likely to be a causal relationship.

c i The prediction for 100% is outside the range of the data (extrapolation) so is less likely to be accurate.

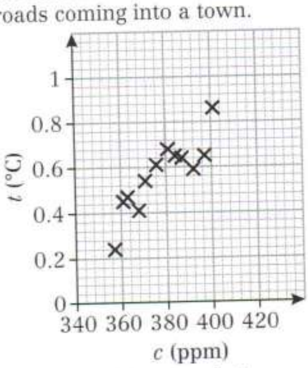
ii The regression equation should only be used to predict a value for v given h.

d Data is only useful for analysing the first two weeks of September. Random values throughout September should be used and analysis made of the whole month. The sample size could also be increased across multiple months as data between May and October is available. Data from 1987 and data from other locations could also be used.

Mixed exercise 4

1 The data shows that the number of serious road accidents in a week strongly correlates with the number of fast food restaurants. However, it does not show whether the relationship is causal. Both variables could correlate with a third variable, e.g. the number of roads coming into a town.

2 a



b Strong positive correlation.

c As mean CO_2 concentration in the atmosphere increases, mean global temperatures also increase.

3 a Strong positive correlation.

b If the number of items increases by 1, the time taken increases by approximately 2.64 minutes.

4 (1) 3500 is outside the range of the data (extrapolation). (2) The regression equation should only be used to predict a value of GNP (y) given energy consumption (x).

5 a Mean + 2SD = 15.2 + 2 × 11.4 = 38; 50 > 38

b The outlier should be omitted as it is very unlikely that the average temperature was 50 °C.

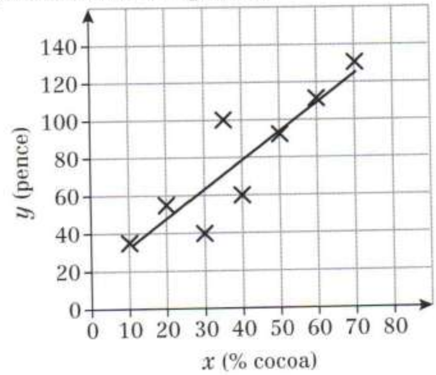
c If the temperature increases by approximately 1 °C, the number of pairs of gloves sold each month decreases by 5.2.

6 a 44 is the length in centimetres of the spring with no mass attached. If a mass of 1 g is attached, the spring would increase in length by approximately 0.2 cm.

b i Outside the range of the data (extrapolation)

ii The regression equation should only be used to predict a value of s given m

7 a & b

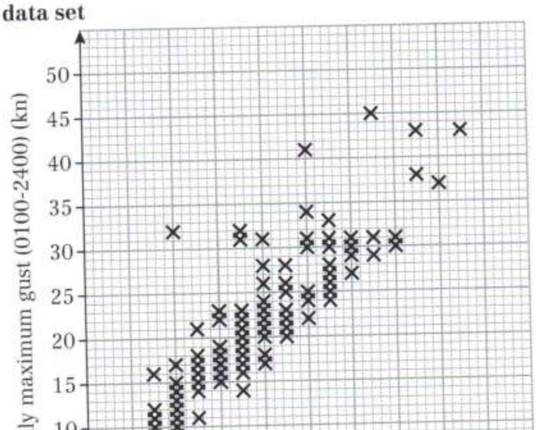


c Brand D is overpriced, since it is a long way above the line.

d The regression equation should be used to predict a value for y given x so the student's method is valid.

Large data set

1 a



b Moderate positive correlation.

c The relationship is causal as the maximum gust is related to the mean windspeed.

d i 6.05 **ii** 15.7 **iii** 30.8 **iv** 91.0

e Parts **ii** and **iii** are within the range of the data (interpolation) so are more likely to be accurate. Parts **i** and **iv** are outside the range of the data (extrapolation) so are less likely to be accurate.

f $w = 0.053 + 0.35g$; 10.6 knots

2 a Regression equation: $s = 14.6 - 1.7c$
Estimated missing values: 2.7, 7.8, 6.1, 11.2, 2.7, 7.8, 11.2, 14.6, 9.5, 6.1, 2.7, 4.4, 7.8, 2.7, 4.4, 4.4, 1.0

b The relationship is causal because daily sunshine is related to daily mean cloud cover.

CHAPTER 5

Prior knowledge 5

1 a $\frac{2}{9}$ **b** $\frac{4}{9}$ **c** $\frac{2}{3}$ **d** 0

2 HHH, HHT, HTH, HTT, THH, THT, TTH, TTT

3 a $\frac{25}{216}$

b $\frac{11}{36}$

c $\frac{125}{216}$

Exercise 5A

1 $\frac{1}{2}$

2 a

		Second roll					
		1	**2**	**3**	**4**	**5**	**6**
First roll	**1**	1	2	3	4	5	6
	2	2	4	6	8	10	12
	3	3	6	9	12	15	18
	4	4	8	12	16	20	24
	5	5	10	15	20	25	30
	6	6	12	18	24	30	36

b i $\frac{1}{18}$ **ii** $\frac{2}{9}$ **iii** $\frac{3}{4}$

3 a $\frac{2}{5}$

b $\frac{5}{7}$

c Less likely; frequency uniformly distributed throughout the class.

4 a $\frac{19}{40}$ **b** $\frac{109}{240}$ **c** $\frac{71}{240}$

d $\frac{2}{15}$; distribution of lengths of koalas between 70 cm and 75 cm is uniform.

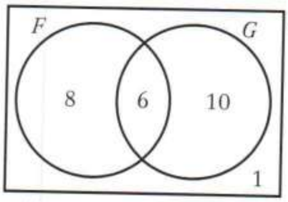
5 a $\frac{16}{35}$

b $\frac{32}{35}$

Challenge:
5, 7 or 9

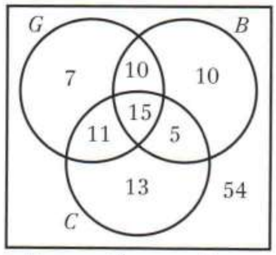
Exercise 5B

1 a



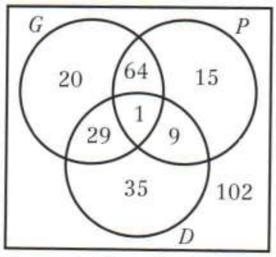
i $\frac{14}{25}$ **ii** $\frac{6}{25}$ **iii** $\frac{8}{25}$ **iv** $\frac{1}{25}$

2 a



b i $\frac{3}{25}$ **ii** $\frac{2}{25}$ **iii** $\frac{2}{25}$ **iv** $\frac{54}{125}$

3 a i



b i $\frac{89}{275}$ **ii** $\frac{103}{275}$ **iii** $\frac{14}{55}$ **iv** $\frac{102}{275}$

4 a 0.17

b 0.18

c 0.55

5 a 0.3

b 0.3

6 a 0.15

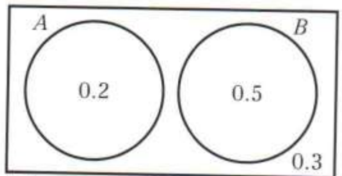
b 0.15

7 $p = 0.13$, $q = 0.25$

Challenge
$p = 0.115$, $q = 0.365$, $r = 0.12$

Exercise 5C

1 a



b 0.7 **c** 0.3

2 Rolling two 2s fits both conditions, so the events are not mutually exclusive.

3 0.15

4 0.3

5 a Bricks and trains; their curves do not overlap.

b Not independent.

6 a 0.25 **b** Not independent

7 a P(S and T) = 0.3 − 0.18 = 0.12
P(S) × P(T) = 0.3 × 0.4 = 0.12 = P(S and T)
So S and T are independent.

b i 0.12 **ii** 0.42

8 P(W) × P(X) = 0.5 × 0.45 = 0.225
P(W and X) = 0.25, so W and X are **not** independent.

9 a $x = 0.15$, $y = 0.3$

b P(F and R) = 0.15 ≠ P(F) × P(R) = 0.45 × 0.4 = 0.18

10 $p = 0.14$ and $q = 0.33$ or $p = 0.33$ and $q = 0.14$

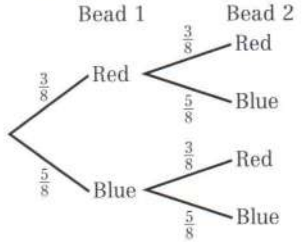
Challenge

a Set P(A) = p and P(B) = q, then P(A and B) = pq
P(A and not B) = P(A) − P(A and B) = $p - pq$
P(not B) = $1 - q$
⇒ P(A) × P(not B) = $p(1 - q) = p - pq$ = P(A and not B)

b P(not A and not B) = 1 − P(A or B)
$= 1 - \text{P}(A) - \text{P}(B) + \text{P}(A \text{ and } B)$
$= 1 - p - q + pq = (1 - p)(1 - q)$
But P(not A) = $1 - p$ and P(not B) = $1 - q$, so
P(not A and not B) = P(not A) × P(not B)

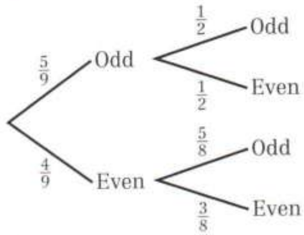
Exercise 5D

1 a



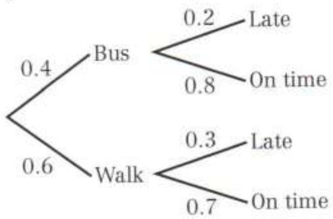
b $\frac{25}{64}$ **c** $\frac{5}{8}$

2 a



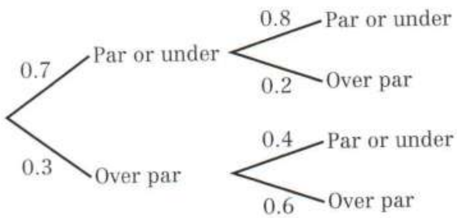
b $\frac{1}{6}$ **c** $\frac{5}{9}$

3 a



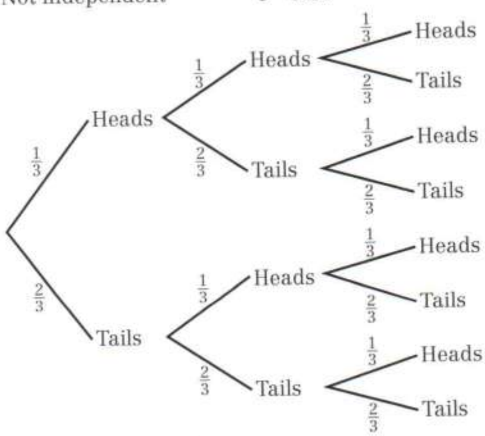
b 0.26

4 a



b Not independent **c** 0.26

5 a



b $\frac{1}{27}$ **c** $\frac{4}{9}$ **d** $\frac{1}{9}$

6 a $\frac{5}{26}$ **b** $\frac{4}{11}$ **c** $\frac{36}{143}$

Mixed exercise 5

1 a $\frac{392}{3375}$ **b** $\frac{14}{75}$

2 a 0.0397 **b** 0.286 **c** 0.714

3 a $\frac{64}{125}$

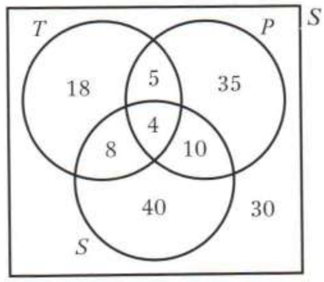
b $\frac{8}{25}$

c $\frac{33}{250}$

d $\frac{74}{125}$, using interpolation and assuming uniform distribution of scores

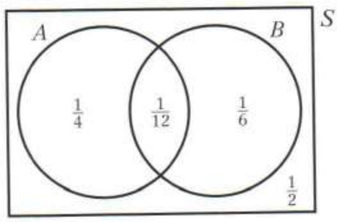
4 a $\frac{22}{25}$ **b** $\frac{77}{100}$

5 a



b i 0.2 **ii** 0.82

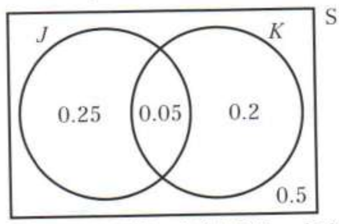
6 a



b P(A) = $\frac{1}{3}$, P(B) = $\frac{1}{4}$, P(A and B) = $\frac{1}{12}$
P(A) × P(B) = P(A and B), so A and B are independent.

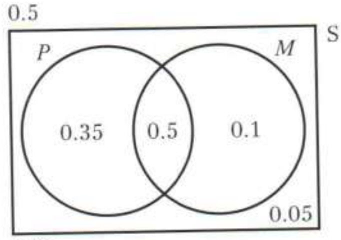
7 a Cricket and swimming
b Not independent

8 a



b P(J) = 0.3, P(K) = 0.25, P(J and K) = 0.05
P(J) × P(K) = 0.075 ≠ P(J and K), so J and K are not independent.

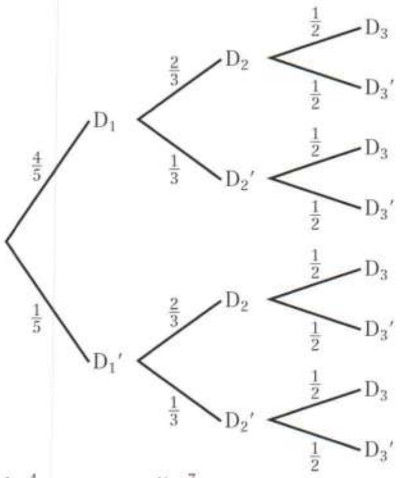
9 a 0.5
b



c 0.35
d No. P(P) = 0.85 and P(M) = 0.6, so
P(P) × P(M) = 0.51 ≠ P(P and M)

10 Not independent

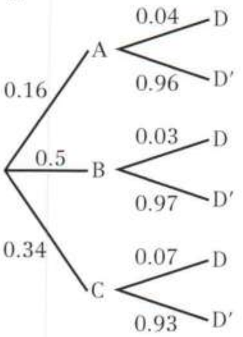
11 a



b **i** $\frac{4}{15}$ **ii** $\frac{7}{30}$

c $\frac{11}{15}$

12 a



b **i** 0.015 **ii** 0.0452

Challenge
0.2016

CHAPTER 6

Prior knowledge 6

1 **a** $\frac{1}{8}$ **b** $\frac{1}{8}$ **c** $\frac{3}{8}$ **d** $\frac{1}{2}$

2 **a** $\frac{1}{9}$ **b** $\frac{1}{2}$ **c** $\frac{1}{2}$ **d** $\frac{1}{3}$ **e** $\frac{5}{12}$

Exercise 6A

1 **a** This is not a discrete random variable, since height is continuous quantity.
b This is a discrete random variable, since it is always a whole number and it can vary.
c This is not a discrete random variable, since the number of days in a given week is always 7.

2 0, 1, 2, 3, 4

3 **a** (2, 2) (2, 3) (3, 2) (3, 3)
b **i**

x	4	5	6
$P(X = x)$	0.25	0.5	0.25

ii
$$P(X = x) = \begin{cases} 0.25, & x = 4, 6 \\ 0.5, & x = 5 \end{cases}$$

4 $\frac{1}{12}$

5 $k + 2k + 3k + 4k = 1$,
so $10k = 1$, so $k = \frac{1}{10}$.

6 **a** 0.125 **b** 0.875

7 **a** 0.3
b

x	−2	−1	0	1	2
$P(X = x)$	0.1	0.1	0.3	0.3	0.2

c 0.7

8 0.25

9 **a** 0.02 **b** 0.46 **c** 0.56

10 **a** 0.625 **b** 0.375 **c** 0

11 **a**

s	1	2	3	4
$P(S = s)$	$\frac{2}{3}$	$\frac{2}{9}$	$\frac{2}{27}$	$\frac{1}{27}$

b $\frac{1}{9}$

12 **a**

x	$P(X = x)$
0	0.07776
1	0.2592
2	0.3456
3	0.2304
4	0.0768
5	0.01024

b

y	$P(Y = y)$
0	0.32768
1	0.4096
2	0.2048
3	0.0512
4	0.0064
5	0.00032

c

z	$P(Z = z)$
1	0.4
2	0.24
3	0.144
4	0.0864
5	0.1296

13 **a** The sum of the probabilities is not 1.
b $2\frac{22}{61}$

Challenge
0.625

Exercise 6B

1 **a** 0.273 **b** 0.0683 **c** 0.195

2 **a** 0.00670 **b** 0.214 **c** 0.00178

3 **a** $X \sim B(20, 0.01)$, $n = 20$, $p = 0.01$
Assume bolts being defective are independent of each other.
b $X \sim B(6, 0.52)$, $n = 6$, $p = 0.52$
Assume the lights operate independently and the time lights are on/off is constant.
c $X \sim B(30, \frac{1}{8})$, $n = 30$, $p = \frac{1}{8}$
Assume serves are independent and probability of an ace is constant.

4 **a** $X \sim B(14, 0.15)$ is OK if we assume the children in the class being Rh^- is independent from child to child (so no siblings/twins).

b This is not binomial since the number of tosses is not fixed. The probability of a head at each toss is constant ($p = 0.5$) but there is no value of n.
c Assuming the colours of the cars are independent
X = number of red cars out of 15
$X \sim B(15, 0.12)$

5 a 0.358 **b** 0.189

6 a The random variable can take two values, faulty or not faulty.
There are a fixed number of trials, 10, and fixed probability of success: 0.08.
Assuming each member in the sample is independent, a suitable model is $X \sim B(10, 0.08)$
b 0.00522

7 a Assumptions: There is a fixed sample size, there are only two outcomes for the genetic marker (i.e. fully present or not present), there is a fixed probability of people having the marker.
b 0.0108

8 a The random variable can take two values, 6 or not 6. There are a fixed number of trials (15) and a fixed probability of success (0.3), Each roll of the dice is independent. A suitable distribution is $X \sim B(15, 0.3)$
b 0.219 **c** 0.127

Exercise 6C

1 a 0.9804 **b** 0.7382 **c** 0.5638 **d** 0.3020
2 a 0.9468 **b** 0.5834 **c** 0.1272 **d** 0.5989
3 a 0.5888 **b** 0.7662 **c** 0.1442 **d** 0.2302
4 a 0.8882 **b** 0.7992 **c** 0.0599 **d** 0.1258
5 a 0.0039 **b** 0.9648 **c** 0.3633
6 a 0.2252 **b** 0.4613 **c** 0.7073
7 a $k = 13$ **b** $r = 28$
8 a $k = 1$ **b** $r = 9$ **c** 0.9802
9 a $X \sim B(10, 0.30)$ Assumptions: The random variable can take two values (listen or don't listen), there are a fixed number of trials (10) and a fixed probability of success (0.3), each member in the sample is independent.
b 0.1503 **c** $s = 8$
10 a 0.2794 **b** 0.0378 **c** $d = 5$

Mixed exercise 6

1 a

x	$P(X = x)$
1	$\frac{1}{21}$
2	$\frac{2}{21}$
3	$\frac{3}{21}$
4	$\frac{4}{21}$
5	$\frac{5}{21}$
6	$\frac{6}{21}$

b $\frac{12}{21}$

2 a 0.2 **b** 0.7

3 a

x	1	2	3	4
$P(X = x)$	$\frac{1}{13}$	$\frac{5}{26}$	$\frac{4}{13}$	$\frac{11}{26}$

b $\frac{19}{26}$

4 a The probabilities must be the same.
b **i** 0.0625 **ii** 0.375 **iii** 0.5

5 a 15
b

y	1	2	3	4	5
$P(Y = y)$	$\frac{1}{15}$	$\frac{2}{15}$	$\frac{3}{15}$	$\frac{4}{15}$	$\frac{5}{15}$

c $\frac{3}{5}$

6 a

t	0	1	2	3	4
$P(T = t)$	$\frac{81}{256}$	$\frac{108}{256}$	$\frac{54}{256}$	$\frac{12}{256}$	$\frac{1}{256}$

b $\frac{243}{256}$
c

s	1	2	3	4	5
$P(S = s)$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{9}{64}$	$\frac{27}{256}$	$\frac{81}{256}$

d $\frac{9}{16}$

7 a 0.114 **b** 0.0005799
c 0.9373
8 a 0.0439 **b** 0.273
9 a 0.014 (3 d.p.) **b** 0.747 (3 d.p.)
10 a 1 There are n independent trials.
2 n is a fixed number.
3 The outcome of each trial is success or failure.
4 The probability of success at each trial is constant.
b 0.0861 **c** $n = 90$
11 a 0.000977 **b** 0.0547
12 a 0.0531 **b** 0.243
13 a $X \sim B(10, 0.15)$
b 0.0099 **c** 0.2759
14 a 0.8692 **b** 0.0727
15 a 0.8725 **b** 0.01027 **c** 0.0002407

Challenge
0.001244

CHAPTER 7

Prior knowledge 7

1 a 0.075 **b** 0.117
c 0.0036 **d** 0.00000504
2 a $X \sim B(8, \frac{1}{6})$ **b** **i** 0.260 **ii** 0.0307

Exercise 7A

1 a A hypothesis is a statement made about the value of a population parameter. A hypothesis test uses a sample or an experiment to determine whether or not to reject the hypothesis.
b The null hypothesis (H_0) is what we assume to be correct and the alternative hypothesis (H_1) tells us about the parameter if our assumption is shown to be wrong.
c The test statistic is used to test the hypothesis. It could be the result of the experiment or statistics calculated from a sample.

2 a One-tailed test
b Two-tailed test
c One-tailed test

3 a The test statistic is N – the number of sixes.
b H_0: $p = \frac{1}{6}$ **c** H_1: $p > \frac{1}{6}$

4 a Shell is describing what her experiment wants to test rather than the test statistic. The test statistic is the number of times you get a head.
b H_0: $p = \frac{1}{2}$ **c** H_1: $p \neq \frac{1}{2}$

5 a A suitable test statistic is p – the number of faulty articles in a batch.

b $H_0: p = 0.1$, $H_1: p < 0.1$
c If the probability of getting 8 or fewer faulty items is 5% or less the null hypothesis is rejected.

6 a A suitable test statistic is the number of voters out of 20 that support the candidate.
b $H_0: p = 0.55$, $H_1: p < 0.55$
c If the probability of getting 7 or fewer is more than 2% then the null hypothesis would be accepted.

Exercise 7B

1 a The critical value is the first value to fall inside of the critical region.
b A critical region is a region of the probability distribution which, if the test statistic falls within it, would cause you to reject the null hypothesis.
c The acceptance region is the area in which we accept the null hypothesis.

2 The critical region is $X \geqslant 5$ since $P(X \geqslant 5) = 0.0328 < 0.05$.

3 $P(X = 0) = 0.0387 < 0.05$, so the critical region is $X = 0$.

4 a The critical region is $X \geqslant 13$ and $X \leqslant 3$.
b $0.037 = 3.7\%$

5 The critical value is $x = 0$. The critical region is $X = 0$.

6 a $X \geqslant 5$.
b 4.79% (3 s.f.)

7 a The number of times the sample fails.
b $H_0: p = 0.3$, $H_1: p < 0.3$
c The critical region is $X \leqslant 2$
d 3.55%

8 a The number of seedlings that survive. $H_0: p = \frac{1}{3}, H_1: p > \frac{1}{3}$
b critical region is $X \geqslant 17$
c 5.84%

9 a Model as $B(n, p)$; $H_0: p = 0.2$, $H_1: p \neq 0.2$
b The critical region is $X \leqslant 1$ and $X \geqslant 10$
c 4.47%

Challenge

a The critical region is $X \leqslant 29$ and $X \geqslant 41$
b Chance of one observation falling within critical region = 8.8%.
Chance of two observations falling within critical region = 0.77%.

Exercise 7C

1 $0.0781 > 0.05$
There is insufficient evidence to reject H_0.

2 $0.0464 < 0.05$
There is sufficient evidence to reject H_0 so $p < 0.04$.

3 $0.0480 < 0.05$
There is sufficient evidence to reject H_0 so $p > 0.30$.

4 $0.0049 < 0.01$
There is sufficient evidence to reject H_0 so $p < 0.45$.

5 $0.0526 > 0.05$
There is insufficient evidence to reject H_0 so there is no reason to doubt $p = 0.28$.

6 $0.0020 < 0.05$
There is sufficient evidence to reject H_0 so $p > 0.32$.

7 $0.3813 > 0.05$
There is insufficient evidence to reject H_0 (not significant).
There is no evidence that the probability is less than $\frac{1}{6}$.
There is no evidence that the dice is biased.

8 a Distribution $B(n, 0.68)$.
Fixed number of trials.
Outcomes of trials are independent.
There are two outcomes success and failure.
The probability of success is constant.
b $P(X \leqslant 3) = 0.0155 < 0.05$. There is sufficient evidence to reject the null hypothesis so $p < 0.68$. The treatment is not as effective as claimed.

9 a Critical region is $X \geqslant 13$
b 14 lies in the critical region, so we can reject the null hypothesis. There is evidence that the new technique has improved the number of plants that germinate.

10 a The number of people who support the candidate. $H_0: p = 0.35$, $H_1: p > 0.35$
b Critical region is $X \geqslant 24$
c 28 lies in the critical region, so we can reject the null hypothesis. There is evidence that the candidate's level of popularity has increased.

Exercise 7D

1 $P(X \leqslant 10) = (0.0494 > 0.025$ (two-tailed)
There is insufficient evidence to reject H_0 so there is no reason to doubt $p = 0.5$

2 $P(X \geqslant 10) = 0.189 > 0.05$ (two tailed)
There is insufficient evidence to reject H_0 so there is no reason to doubt $p = 0.3$

3 $(X \geqslant 9) = 0.244 > 0.025$ (two-tailed)
There is insufficient evidence to reject H_0 so there is no reason to doubt $p = 0.75$

4 $P(X \leqslant 1) = 0.00000034 < 0.005$ (two-tailed)
$X = 1$ lies within the critical region, so we can reject the null hypothesis.

5 $P(X \geqslant 4) = 0.0178 > 0.01$ (two-tailed)
There is insufficient evidence to reject H_0 so there is no reason to doubt $p = 0.02$

6 $P(X \leqslant 6) = 0.0577 > 0.025$ (two-tailed)
$X = 6$ does not lie in the critical region, so there is no reason to think that the coin is biased.

7 a Critical region $X = 0$ and $X \geqslant 8$
b 4.37%
c $X = 8$ is in the critical region. There is enough evidence to reject H_0. The hospital's proportion of complications differs from the national figure.

8 Test statistic: the number of cracked bowls.
$H_0: p = 0.1$, $H_1: p \neq 0.1$
$P(X \leqslant 1) = 0.3917 = 39.17\%$
$39.17\% > 5\%$ (two-tailed) so there is not enough evidence to reject H_0. The proportion of cracked bowls has not changed.

9 Test statistic: the number of carrots longer than 7 cm
$H_0: p = 0.25$, $H_1: p \neq 0.25$
$P(X \geqslant 13) = 1 - P(X \leqslant 12) = 0.0216 = 2.16\%$
$2.16\% < 2.5\%$ (two-tailed) so there is enough evidence to reject the null hypothesis. The probability of a carrot being longer than 7 cm has changed.

10 Test statistic: the number of patients correctly diagnosed.
$H_0: p = 0.96$, $H_1: p \neq 0.96$
$P(X \leqslant 63) = 0.0000417 < 0.05$ (two-tailed) so there is enough evidence to reject the null hypothesis. The new test does not have the same probability of success as the old test.

Mixed exercise 7

1 $H_0: p = 0.2$, $H_1: p > 0.2$, $P(X \geqslant 3) = 0.3222 > 0.05$
There is insufficient evidence to reject H_0.
There is no evidence that the trains are late more often.

2 $H_0: p = 0.5$, $H_1: p > 0.5$, $P(X \geqslant 4) = 0.1875 > 0.05$
There is insufficient evidence to reject H_0.
There is insufficient evidence that the manufacturer's claim is true.

3 **a** Fixed number; independent trials; two outcomes (pass or fail); p constant for each car.
b 0.16807
c $0.3828 > 0.05$
There is insufficient evidence to reject H_0.
There is no evidence that the garage fails fewer than the national average.

4 **a** Critical region $X \leqslant 1$ and $X \geqslant 10$.
b 0.0583
c $H_0: p = 0.1$, $H_1: p > 0.1$, $P(X \geqslant 4) = 0.133 > 0.1$.
Accept H_0. There is no evidence that the proportion of defective articles has increased.

5 $H_0: p = 0.5$, $H_1: p \neq 0.5$, $P(X \leqslant 8) = 0.252 > 0.025$ (two-tailed)
There is insufficient evidence to reject H_0.
There is no evidence that the claim is wrong.

6 **a** Critical region is $X \leqslant 4$ and $X \geqslant 16$
b 0.0493
c There is insufficient evidence to reject H_0.
There is no evidence to suggest that the proportion of people buying that certain make of computer differs from 0.2.

7 **a** **i** The theory, methods, and practice of testing a hypothesis by comparing it with the null hypothesis.
ii The critical value is the first value to fall inside of the critical region.
iii The acceptance region is the region where we accept the null hypothesis.
b Critical region $X = 0$ and $X \geqslant 8$
c 4.37%
d As 7 does not lie in the critical region, H_0 is not rejected. Therefore, the proportion of times that Johan is late for school has not changed.

8 $P(X \geqslant 21) = 0.021 < 0.05$. Therefore there is sufficient evidence to support Poppy's claim that the likelihood of a rain-free day has increased.

9 **a** Critical region $X \leqslant 5$ and $X \geqslant 16$
b 5.33%
c $X = 4$ is in the critical region so there is enough evidence to reject H_0.

10 **a** $X \sim B(20, 0.85)$
b 0.1821
c Test statistic is proportion of patients who recover.
$H_0: p = 0.85$, $H_1: p < 0.85$
$P(X \leqslant 20) = 0.00966$
$0.00966 < 0.05$ so there is enough evidence to reject H_0. The percentage of patients who recover after treatment with the new ointment is lower than 85%.

Large data set

1 **a** The critical region is $X \geqslant 5$
b Students' answers
c Students' answers

2 Students' answers

Review exercise 1

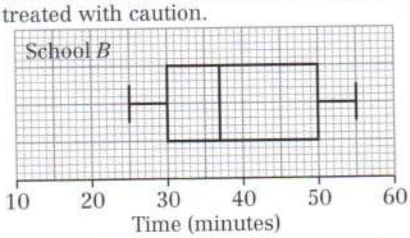
1 **a** A census observes every member of a population. Disadvantage it would be time-consuming to get opinions from all the employees.
b Opportunity sampling
c Only cleaners – no managers i.e. not all types. Not a random sample – 1st 50 may be in same shift/group/share same views.
d **i** Label employees (1–550) or obtain an ordered list. Select first person using random numbers (from 1–11). Then select every 11th person from the list e.g. If person 8 is selected then the sample is 8, 19, 30, 41, …
ii Label managers (1–55) and cleaners (1–495). Use random numbers to select 5 managers and 45 cleaners.

2 **a** Opportunity sampling is using a sample that is available at the time the study is carried out. It is unlikely to provide a representative sample of the weather in May.
b 87.4
c Relative humidity above 95% gives rise to misty conditions. 4 out of 5 observations are not misty days, so she may be right. However, 5 days is not a representative sample for the whole of May.

3 **a** Median 27.2 miles
b Mean 30.1 miles, standard deviation 16.6 miles

4 Mean 3.06 hours, standard deviation 3.32 hours

5 **a** **i** 37 minutes
ii upper quartile, third quartile, 75 percentile
b Outliers – values that are much greater than or much less than the other values and need to be treated with caution.
c

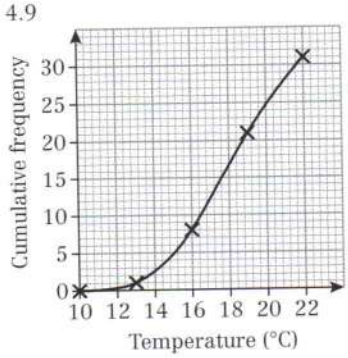


d The children from school A generally took less time than those from school B. The median for A is less than the median for B. A has outliers, but B does not. The interquartile range for A is less than the interquartile range for B. The total range for A is greater than the total range for B.

6 **a** Missing frequencies: 35, 15; Missing frequency densities: 4, 6
b 0.4
c 18.9 minutes
d 7.26 minutes
e 18 minutes

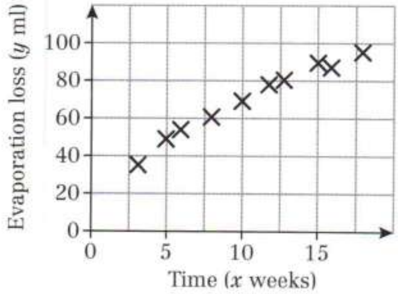
7 0.82

8 **a** 4.9
b



c Interpolation likely to be more accurate.
d 25 days

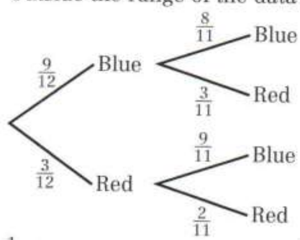
9 a



b The points lie close to a straight line.
c 3.90 ml of the chemicals evaporate each week.
d The estimate for 19 weeks is reasonably reliable, since it is just outside the range of the data. The estimate for 35 weeks is unreliable, since it is far outside the range of the data.

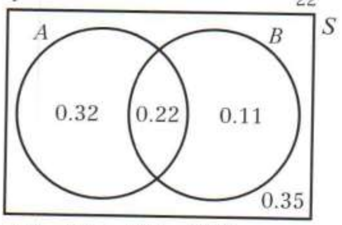
10 a $15.3 + 2 \times 10.2 = 35.7$ so 45 is an outlier
b A temperature of 45 °C is very high so it is likely this value was recorded incorrectly.
c When the temperature increases by 1 °C, the number of ice creams sold per month increases by 281.
d Outside the range of the data (extrapolation)

11 a



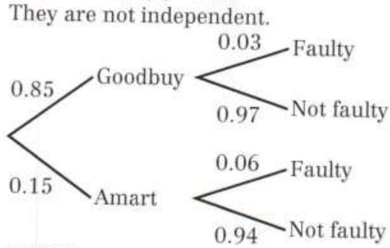
b $\frac{1}{4}$ c $\frac{9}{22}$

12 a



b P(A) = 0.54, P(B) = 0.33
c They are not independent.

13 a



b 0.9655

14 a C and T
b $P(C \text{ and } B) = 0.34$; $P(C) \times P(B) = 0.32$ so the events are not independent

15 a 0.375
b 0.125
c 0.125

16 a 0.0278
b 0.8929
c 0.0140

17 a

x	$P(X = x)$
1	0.0278
2	0.0833
3	0.1389
4	0.1944
5	0.2500
6	0.3056

b 0.5833

18 a $P(X = x) = 0.2$ for $x = 1, 2, 3, 4, 5$
b

y	1	2	3	4
$P(Y = y)$	0.6	0.24	0.096	0.064

c 0.16

19 a 0.101 b 0.448 c 0.929 d 0.339

20 a $0 \leqslant X \leqslant 5$ and $19 \leqslant X \leqslant 40$
b 0.0234

21 a $X \sim B(10, 0.75)$
where X is the random variable 'number of patients who recover when treated'.
b 0.146
c H_0: $p = 0.75$ H_1: $p < 0.75$. $0.2142 > 0.05$ so there is insufficient evidence to reject H_0.
d 9

22 a H_0: $p = 0.3$, H_1: $p > 0.3$
b $18 \leqslant X \leqslant 40$
c 3.2%
d Reject the null hypothesis. Dhiriti's claim is supported.

Challenge

1 $x = 4$, $y = 6$, $z = 14$
2 a $X \leqslant 16$ (probability = 0.1263)
b 0.0160

CHAPTER 8

Prior knowledge 8

1 a $x = 4$ or $x = \frac{1}{5}$ b $x = \frac{3}{2}$ or $x = -\frac{7}{3}$
c $x = 2.26$ or $x = -0.591$ d $x = \pm\frac{3}{2}$
2 a $x = 10.3$, $y = 60.9°$ b $x = 14.8$, $y = 8.7$
3 a $833\,\text{cm s}^{-1}$ b $5000\,\text{kg m}^{-3}$
4 a 7.65×10^6 b 3.806×10^{-3}

Exercise 8A

1 a i $h = 0$ ii $h = 6$ m
b $h = -48$ m.
c Model is not valid when $x = 200$ as height would be 48 m below ground level.
2 a 90 m b i $h = 90$ m ii $h = 40$ m
c $h = -1610$ m
d Model is not valid when $t = 20$ as height would be 1610 m below sea level.
3 a $x = 2.30$ m or 8.70 m b $k = 10$ m
c When $k = 10$ m the ball passes through the net so model not valid for $k > 10$
4 a 1320 m
b Model is valid for $0 \leqslant t \leqslant 10$
5 $0 \leqslant x \leqslant 120$
6 $0 \leqslant t \leqslant 6$

Exercise 8B

1 a Ignore the rotational effect of any external forces that are acting on it, and the effects of air resistance.
  b Ignore the frictional effects on the football due to air resistance.

2 a Ignore the rotational effect of any external forces that are acting on it, and the effects of air resistance.
  b Ignore any friction between the ice puck and the ice surface.

3 Modelling an object as a particle means that the effect of air resistance is ignored, but for a parachute, this force is significant.

4 a If modelled as a light rod, the fishing rod is considered to have no thickness and is rigid.
  b If the fishing rod had no thickness and was rigid it would be unsuitable for fishing.

5 a Model golf ball as a particle, ignore the effects of air resistance.
  b Model child on sledge as a particle, consider the hill as smooth.
  c Model objects as particles, string as light and inextensible, pulley as smooth.
  d Model suitcase and handle as a particle, path as smooth, ignore friction.

Exercise 8C

1 a $18.1\,\text{m s}^{-1}$ b $150\,\text{kg m}^{-2}$ c $5 \times 10^{-3}\,\text{m s}^{-1}$
  d $0.024\,\text{kg m}^{-3}$ e $45\,\text{kg m}^{-3}$ f $63\,\text{kg m}^{-2}$

2 a A: Normal reaction, B: Forward thrust, C: Weight, D: Friction.
  b A: Buoyancy, B: Forward thrust, C: Weight, D: Water resistance or drag.
  c A: Normal reaction, B: Friction, C: Weight, D: Tension.
  d A: Normal reaction, B: Weight, C: Friction.

Exercise 8D

1 a $2.1\,\text{m s}^{-1}$ b $500\,\text{m}$ c $-1.8\,\text{m s}^{-1}$
  d $-2.7\,\text{m s}^{-1}$ e $-750\,\text{m}$ f $2.5\,\text{m s}^{-1}$

2 a $15.6\,\text{m s}^{-1}$ b $39.8°$

3 a $5\,\text{m s}^{-2}$ b $143°$

4 a $15.3\,\text{km}$ b $24.3\,\text{km}$ c $78.7°$

Mixed exercise 8

1 a $3.6\,\text{m}$ b $1\,\text{m}$ and $7\,\text{m}$
  c $0 \leqslant x \leqslant 8$ d $4.8\,\text{m}$

2 a $7.68\,\text{m}$ b $4.15\,\text{m}$
  c Ignore the effects of air resistance on the diver and rotational effects of external forces.
  d Assumption not valid, diver experiences drag and buoyancy in the water.

3 a Model the man on skis as a particle – ignore the rotational effect of any forces that are acting on the man as well as any effects due to air resistance. Consider the snow-covered slope as smooth – assume there is no friction between the skis and the snow-covered slope.
  b Model the yo-yo as a particle – ignore the rotational effect of any forces that are acting on the yo-yo as well as any effects due to air resistance. Consider the string as light and inextensible – ignore the weight of the string and assume it does not stretch. Model the yo-yo as smooth – assume there is no friction between the yo-yo and the string.

4 a $41.7\,\text{m s}^{-1}$
  b $6000\,\text{kg m}^{-2}$
  c $1.2 \times 10^{6}\,\text{kg m}^{-3}$

5 a Model ball as a particle. Assume the floor is smooth.
  b i Positive – the positive direction is defined as the direction in which the ball is travelling.
    ii Negative – the ball will be slowing down.

6 a Velocity is positive, displacement is positive
  b Velocity is negative, displacement is positive
  c Velocity is negative, displacement is negative

7 a $0.158\,\text{ms}^{-2}$ b $108.4°$

8 a $4.3\,\text{ms}^{-1}$ b $125.5°$

9 a $158.1\,\text{m}$ b $186.4\,\text{m}$ c $51.3°$

CHAPTER 9

Prior knowledge 9

1 a i 3 ii 73.5
  b i 2 ii 150
  c i −1.5 ii 26.25

2 26.25 miles

3 a $x = 2, y = -1.5$ b $x = 1.27$ or $x = -2.77$

Exercise 9A

1 a A $80\,\text{km h}^{-1}$, B $40\,\text{km h}^{-1}$, C $0\,\text{km h}^{-1}$, D $40\,\text{km h}^{-1}$, E $-66.7\,\text{km h}^{-1}$
  b $0\,\text{km h}^{-1}$ c $50\,\text{km h}^{-1}$

2 a $187.5\,\text{km}$ b $50\,\text{km h}^{-1}$

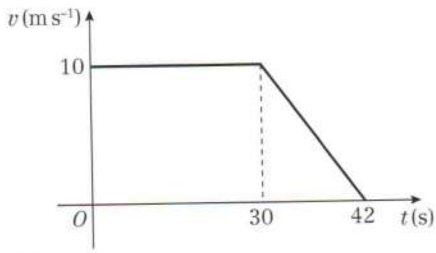
3 a $12\,\text{km h}^{-1}$ b 12:45
  c $-10\,\text{km h}^{-1}$, $3\,\text{km h}^{-1}$ d $7.5\,\text{km h}^{-1}$

4 a $2.5\,\text{m}$, $0.75\,\text{s}$
  b $0\,\text{m s}^{-1}$
  c i The velocity of the ball is positive (upwards). The ball is decelerating until it reaches 0 at the highest point.
    ii The velocity of the ball is negative (downwards), and the ball is accelerating.

Exercise 9B

1 a $2.25\,\text{m s}^{-2}$ b $90\,\text{m}$

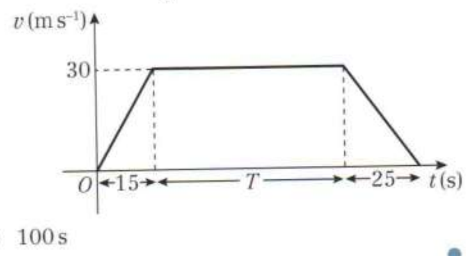
2 a



  b $360\,\text{m}$

3 a $0.4\,\text{m s}^{-2}$ b $\frac{8}{15}\,\text{m s}^{-2}$ or $0.53\,\text{m s}^{-2}$ c $460\,\text{m}$

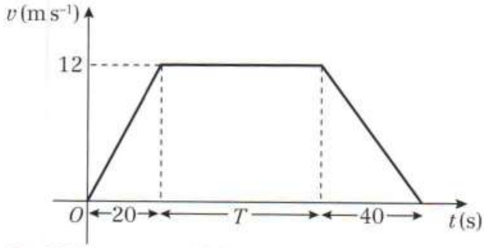
4 a



  b $100\,\text{s}$

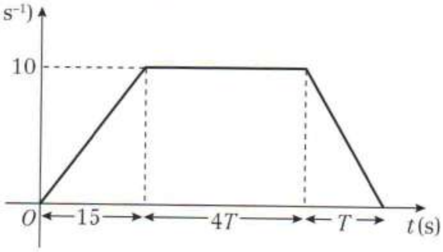
Online Full worked solutions are available in SolutionBank.

5 a



b $T = 320$ **c** 3840 m

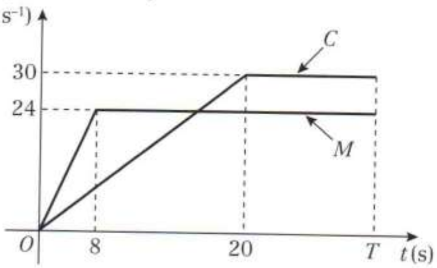
6 a



b 60 s

7 a $u = \frac{10}{3}$ **b** $\frac{20}{9}$ m s^{-2} = 2.22 m s^{-2}

8 a



b 720 m

Challenge

a 6 s **b** 16.5 m
c **i** 10.5 m **ii** 4.5 m

Exercise 9C

1 20 m s^{-1}
2 0.625 m s^{-2}
3 20 m s^{-1}
4 a 9 m s^{-1} **b** 72 m
5 a 3 m s^{-1} **b** $\frac{1}{3}$ m s^{-2}
6 a 9.2 m s^{-1} **b** 33.6 m
7 a 18 km h^{-1} **b** 312.5 m
8 a 8 s **b** 128 m
9 a 0.4 m s^{-2} **b** 320 m
10 a 0.25 m s^{-2} **b** 16 s **c** 234 m
11 a 19 m s^{-1} **b** 2.4 m s^{-2} **c** 430 m
12 a $x = 0.25$ **b** 150 m
13 b 500 m

Challenge

a $t = 3$ **b** 12 m

Exercise 9D

1 7 m s^{-1}
2 $\frac{2}{3}$ m s^{-2}
3 2 m s^{-2}
4 0.175 m s^{-2}
5 a 2.5 m s^{-2} **b** 4.8 s
6 a 3.5 m s^{-1} **b** 15.5 m s^{-1}
7 a 54 m **b** 6 s
8 a 90 m **b** 8.49 m s^{-1} (3 s.f.)
9 a 3.3 s (1 d.p.) **b** 16.2 m s^{-1} (1 d.p.)
10 a $t = 4$ or $t = 8$
b $t = 4$: 4 m s^{-1} in direction $\overrightarrow{AB}$, $t = 8$: 4 m s^{-1} in direction $\overrightarrow{BA}$.
11 a $t = 0.8$ or $t = 4$
b −15.0 m s^{-1} (3 s.f.)
12 a 2 s **b** 4 m
13 a 0.34 m s^{-1} **b** 25.5 s (3 s.f.)
14 a P: $(4t + t^2)$ m Q: $[3(t-1) + 1.8(t-1)^2]$ m
b $t = 6$ **c** 60 m
15 a 4.21 km h^{-2} **b** 0.293 km h^{-1}

Exercise 9E

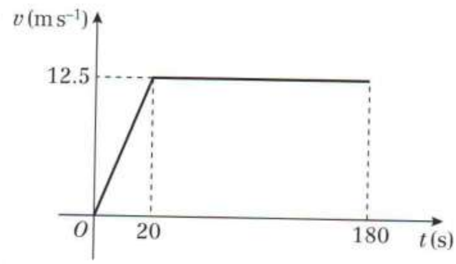
1 a 2.4 s **b** 23.4 m s^{-1}
2 4.1 s (2 s.f.)
3 41 m (2 s.f.)
4 a 29 m (2 s.f.) **b** 2.4 s (2 s.f.)
5 a 5.5 m s^{-1} (2 s.f.) **b** 20 m s^{-1} (2 s.f.)
6 a 40 m s^{-1} (2 s.f.) **b** 3.7 s (2 s.f.)
7 a 39 m s^{-1} **b** 78 m (2 s.f.)
8 4.7 m (2 s.f.)
9 a 3.4 s (2 s.f.) **b** 29 m (2 s.f.)
10 2.8 s (2 s.f.)
11 a $u = 29$ (2 s.f.) **b** 6 s
12 30 m (2 s.f.)
13 a 5.6 m (2 s.f.) **b** 3.2 m (2 s.f.)

Challenge

1 a 1.4 s (2 s.f.) **b** 7.2 m (2 s.f.)
2 155 m (3 s.f.)

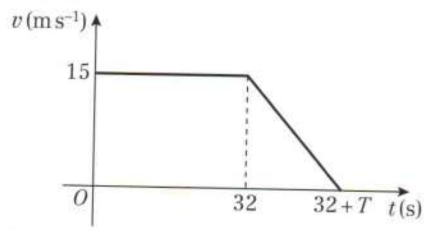
Mixed exercise 9

1 a

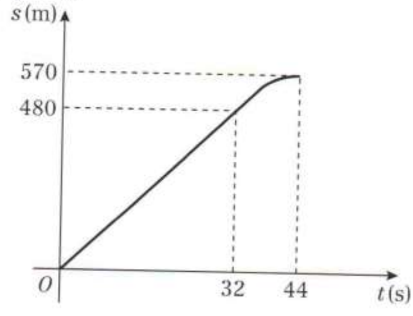


b 2125 m

2 a



b $T = 12$
c



3 a i a = gradient of line. Using the formula for the gradient of a line, $a = \frac{v-u}{t}$, which can be rearranged to give $v = u + at$

ii s = area under the graph. Using the formula for the area of a trapezium, $s = \left(\frac{u+v}{2}\right)t$

b i Substitute $t = \frac{v-u}{a}$ into $s = \left(\frac{u+v}{2}\right)t$

ii Substitute $v = u + at$ into $s = \left(\frac{u+v}{2}\right)t$

iii Substitute $u = v - at$ into $s = \left(\frac{u+v}{2}\right)t$

4 $u = 8$

5 $0.165\,\text{m s}^{-2}$ (3 d.p.)

6 a 60 m **b** 100 m

7 1.9 s

8 a 4.1 s (2 s.f.) **b** $40\,\text{m s}^{-1}$ (2 s.f.) **c** air resistance

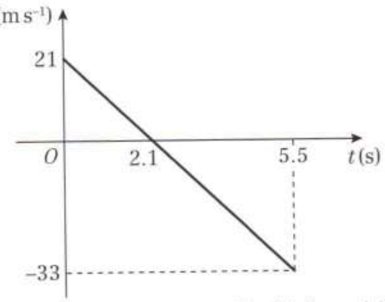
9 a $u = 11$ **b** 22 m

10 a $28\,\text{m s}^{-1}$ **b** 208 m

11 a $8\,\text{m s}^{-1}$ **b** $1.25\,\text{m s}^{-2}$ **c** 204.8 m

12 a $33\,\text{m s}^{-1}$ (2 s.f.) **b** 3.4 s (2 s.f.)

c

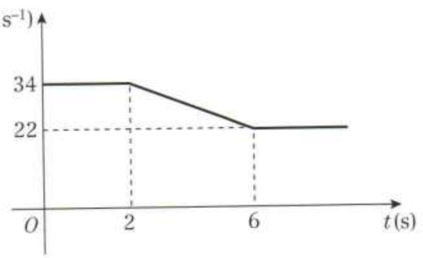


13 a 50 s **b** $24.2\,\text{m s}^{-1}$ (3 s.f.)

14 $h = 39$ (2 s.f.)

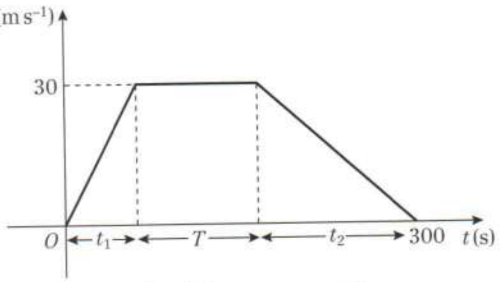
15 a $32\,\text{m s}^{-1}$ **b** 90 m **c** 5 s

16 a



b 180 m

17 a



b $\frac{30}{t_1} = 3x \Rightarrow t_1 = \frac{10}{x}$, $\frac{-30}{t_2} = -x \Rightarrow t_2 = \frac{30}{x}$

So $\frac{10}{x} + T + \frac{30}{x} = 300 \Rightarrow \frac{40}{x} + T = 300$

c $T = 100$, $x = 0.2$ **d** 3 km **e** 125 s

Challenge

1.2 s (2 s.f.)

CHAPTER 10

Prior knowledge 10

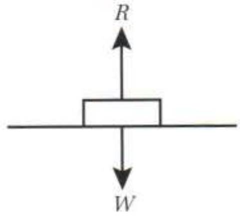
1 a $5\mathbf{i} - 3\mathbf{j}$ **b** $-4\mathbf{i} + 4\mathbf{j}$

2 a 19.2 cm **b** 38.7°

3 a $18\,\text{m s}^{-1}$ **b** 162 m

Exercise 10A

1



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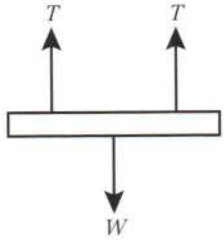
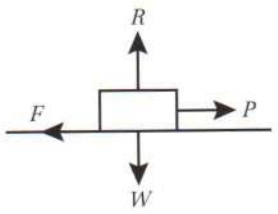


3

4



5

6 Although its speed is constant, the satellite is continuously changing direction. This means that the velocity changes. Therefore, there must be a resultant force on the satellite.

7 5 N

8 a 10 N **b** 30 N **c** 20 N

9 a 200 N

b The platform accelerates towards the ground.

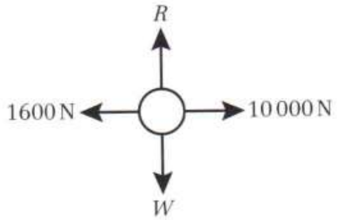
10 $p = 50$, $q = 40$

11 $P = 10\,\text{N}$, $Q = 5\,\text{N}$

12 a i 20 N upwards **ii** accelerates vertically upwards

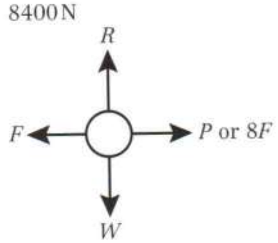
b i 20 N right **ii** accelerates to the right

13 a



b 8400 N

14 a



b 600 N

Exercise 10B

1 a $(3\mathbf{i} + 2\mathbf{j})\,\text{N}$ **b** $\begin{pmatrix} 2 \\ -3 \end{pmatrix}\text{N}$

c $(4\mathbf{i} - 3\mathbf{j})\,\text{N}$ **d** $\begin{pmatrix} 3 \\ -3 \end{pmatrix}\text{N}$

2 a $\mathbf{i} - 8\mathbf{j}$ **b** $-5\mathbf{i} + \mathbf{j}$

3 $a = 3$, $b = 4$

Online Full worked solutions are available in SolutionBank.

4 a i 5 N **ii** $53.1°$
b i $\sqrt{26}$ N **ii** $11.3°$
c i $\sqrt{13}$ N **ii** $123.7°$
d i $\sqrt{2}$ N **ii** $135°$
5 a i $(2\mathbf{i} - \mathbf{j})$ N **ii** $\sqrt{5}$ N **iii** $116.6°$
b i $(3\mathbf{i} + 4\mathbf{j})$ N **ii** 5 N **iii** $036.9°$
6 $a = 3, b = 1$
7 $a = 3, b = -1$
8 a $p = 2, q = -6$ **b** $\sqrt{40}$ N **c** $18°$
9 a $63.4°$ **b** 3.5
10 a $a = 3, b = 2$ **b i** $\sqrt{65}$ N **ii** $30°$

Challenge
$a = 17.3$ (3 s.f.), magnitude of resultant force = 20 N

Exercise 10C

1 $0.3\,\text{m s}^{-2}$
2 39.2 N
3 25 kg
4 $1.6\,\text{m s}^{-2}$
5 a 25.6 N **b** 41.2 N
6 a 2.1 kg (2 s.f.) **b** 1.7 kg (2 s.f.)
7 a $5.8\,\text{m s}^{-2}$ **b** $2.7\,\text{m s}^{-2}$
8 4 N
9 a $0.9\,\text{m s}^{-2}$ **b** 7120 N **c** 8560 N
10 a $0.5\,\text{m s}^{-2}$ **b** 45 N
11 a 32 s **b** 256 m
c The resistive force is unlikely to be constant.

Challenge
a 2.9 m (2 s.f.) **b** $3.6\,\text{m s}^{-1}$ (2 s.f.)
c 2.16 s (3 s.f.)

Exercise 10D

1 a $(0.5\mathbf{i} + 2\mathbf{j})\,\text{m s}^{-2}$
b $2.06\,\text{m s}^{-2}$ (3 s.f.) on a bearing of $014°$ (to the nearest degree).
2 0.2 kg
3 a $(21\mathbf{i} - 9\mathbf{j})$ N
b 22.8 N (3 s.f.) on a bearing of $113°$ (to the nearest degree).
4 a $(-4\mathbf{i} + 32\mathbf{j})\,\text{m s}^{-2}$ **b** $(\frac{5}{6}\mathbf{i} - \frac{1}{6}\mathbf{j})\,\text{m s}^{-2}$
c $(-\mathbf{i} - \frac{2}{3}\mathbf{j})\,\text{m s}^{-2}$ **d** $(-\frac{4}{3}\mathbf{i} + 6\mathbf{j})\,\text{m s}^{-2}$
5 a $\sqrt{0.8125}\,\text{ms}^{-2}$ on a bearing of $146°$ (to the nearest degree).
b 6.66 s
6 $\mathbf{R} = (-k\mathbf{i} + 4k\mathbf{j})$ N
So $4k = 3 + q$ (1), $-k = 2 + p$ (2) and $-4k = 8 + 4p$ (3)
Adding equations (1) and (3) gives $4p + q + 11 = 0$
7 a $b = 6$ **b** $6\sqrt{2}$ N
c $\frac{3\sqrt{2}}{2}\,\text{m s}^{-2}$ **d** $\frac{75\sqrt{2}}{4}$ m
8 a $p = 2, q = -6$ **b** $\frac{25\sqrt{2}}{6}$ kg
9 $\frac{6}{7}$ kg
10 a $5 + q = -2k$ (1), $2 + p = k$ (2) and $4 + 2p = 2k$ (3)
Adding equations (1) and (3) gives $2p + q + 9 = 0$
b 0.2 kg

Challenge
$k = 8$

Exercise 10E

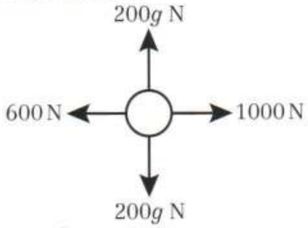
1 a 4 N
b 0.8 N
c Light ⇒ tension is the same throughout the length of the string and the mass of the string does not need to be considered. Inextensible ⇒ acceleration of masses is the same.
2 a 10 kg **b** 40 N
3 a $2\,\text{m s}^{-2}$ **b** 14 N
4 a 16 000 N
b i 880 N upwards
ii 2400 N downwards
5 a 1800 kg and 5400 kg
b 37 000 N
c Light ⇒ tension is the same throughout the length of the tow-bar and the mass of the tow-bar does not need to be considered. Inextensible ⇒ acceleration of lorry and trailer is the same.
6 a $2.2\,\text{ms}^{-2}$ **b** 60 N
7 a 4 kg **b** 47.2 N
8 a 6000 N
b For the carriage, $F = ma = 800$ N
R(→) $800 = T - 2000$, $T = 2800$ N
9 a R(→) $1200 - 100 - 200 = 900$ N
$F = ma$, so $a = 900 \div (300 + 900) = 0.75\,\text{m s}^{-2}$
b 325 N **c** 500 N

Exercise 10F

1 a 33.6 N (3 s.f.)
b $2.37\,\text{m s}^{-1}$ (3 s.f.)
c 2.29 m (3 s.f.)
2 a $2mg$ N
b For P: $2mg - kmg = \frac{1}{3}kmg$
So $2 - k = \frac{1}{3}k$ and $k = 1.5$
c Smooth ⇒ no friction so the tension is the same on both sides of the pulley.
d While Q is descending, distance travelled by $P = s_1$
$s = ut + \frac{1}{2}at^2 \Rightarrow s_1 = \frac{1}{6}g \times 1.8^2 = 0.54g$
Speed of P at this time $= v_1$
$v^2 = u^2 + 2as \Rightarrow v_1{}^2 = 0^2 + \left(2 \times \frac{g}{3} \times 0.54g\right) = 0.36g^2$
After Q hits the ground, P travels freely under gravity and travels a further distance s_2.
$v^2 = u^2 + 2as \Rightarrow 0^2 = 0.36g^2 - 2gs_2 \Rightarrow s_2 = 0.18g$
Total distance travelled $= s_1 + s_2 = 0.54g + 0.18g = 0.72g$ m
As particles started at same height P must be s_1 metres above the plane at the start.
Maximum height reached by P above the plane $= 0.72g + s_1 = 0.72g + 0.54g = 1.26g$ m
3 a $s = ut + \frac{1}{2}at^2$ so $2.5 = 0 + \frac{1}{2} \times a \times 1.25^2$, $a = 3.2\,\text{ms}^{-2}$
b 39 N
c For A, R(↓): $mg - T = ma$
$T = m(9.8 - 3.2)$, $T = 6.6m$
Substituting for T: $39 = 6.6m$
$m = \frac{65}{11}$
d The acceleration of the two particles attached to the string is the same.
e $\frac{40}{49}$ s
4 a $0.613\,\text{m s}^{-2}$ (3 s.f.)
b 27.6 N (3 s.f.)
c 39.0 N (3 s.f.)
5 a i $2.84\,\text{m s}^{-2}$ (3 s.f.)
ii $2.84(1.5) = 1.5g - T$
$T = 1.5g - 4.26 = 10.4$ N (3 s.f.)
iii 3.3 N
b The acceleration of the two particles attached to the string is the same.

Mixed exercise 10

1 a



b $2\,\text{m s}^{-2}$

2 1000 N (2 s.f.) vertically downwards

3 a 2000 N **b** 36 m

4 a $1.25\,\text{ms}^{-2}$ **b** 6 N

5 Res(→) $3R - R = 1200 \times 2 \Rightarrow R = 1200$
Driving force $= 3R = 3600$ N

6 $(28\mathbf{i} + 4\mathbf{j})\,\text{m s}^{-2}$

7 $a = 1, b = -3$

8 a $\sqrt{5}\,\text{m s}^{-2}$ **b** $\frac{9\sqrt{5}}{2}$ m

9 a $a = -15, b = 12$
b i $11.7\,\text{m s}^{-2}$ (3 s.f.) on a bearing of 039.8° (3 s.f.)
ii 52.7 m (3 s.f.)

10 a $0.7\,\text{ms}^{-2}$ **b** 770 N **c** 58 m
d Inextensible ⇒ the acceleration of the car and the trailer is the same.

11 a R(→) $8000 - 500 - R = 3600 \times 1.75$, $R = 1200$ N
b 2425 N **c** 630 N (2 s.f.)

12 a $\frac{1}{3}g\,\text{m s}^{-2}$ **b** $3.6\,\text{m s}^{-1}$ **c** $4\frac{2}{3}$m
d i Acceleration both masses equal.
ii Same tension in string either side of the pulley.

13 a $\frac{12}{7}g$N **b** $m = 1.2$

14 a $3.2\,\text{m s}^{-2}$ **b** 5.3 N (2 s.f.) **c** $F = 3.7$ (2 s.f.)
d The information that the string is inextensible has been use in part **c** when the acceleration of A has been taken to be equal to the acceleration of B.

15 a i $0.5g - T = 0.5a$ **ii** $T - 0.4g = 0.4a$
b $\frac{4}{9}g$N **c** $\frac{1}{9}g\,\text{m s}^{-2}$ **d** 0.66 s (2 s.f.)

Challenge
$k = -\frac{5}{2}$

CHAPTER 11

Prior knowledge 11

1 a $6x - 5$ **b** $x^{-\frac{1}{2}} - 12x^{-3}$

2 a $(1.5, -4.75)$ **b** $(1, 9)$ and $(3, 5)$

3 a $\frac{5x^2}{2} + 8x + 1$ **b** $x^3 - x^2 + 5x + 7$

4 a 18 **b** $11\frac{1}{3}$

Exercise 11A

1 a 8 m **b** $t = 0$ and $t = \pm 3$

2 a 4 m **b** 6 m

3 a $7\,\text{m s}^{-1}$ **b** $9.25\,\text{m s}^{-1}$
c $-11\,\text{m s}^{-1}$; body is travelling in opposite direction.

4 a 0.8 m **b** 4 s
c 1.6 m **d** $0 \leqslant t \leqslant 4$

5 a $8\,\text{m s}^{-1}$ **b** $t = \frac{4}{3}$ and $t = 2$
c $t = \frac{1}{3}$ and $t = 3$ **d** $8\,\text{m s}^{-1}$

6 a 4 s **b** $8\,\text{m s}^{-1}$

7 $T = 3$: returns to starting point and $s = 0$ when $t = 0$ and $t = 3$.

8 a $t = \frac{1}{3}$ and $t = 3$ **b** $\frac{16}{15}\,\text{m s}^{-1}$

Exercise 11B

1 a i $v = 16t^3 + \frac{1}{t^2}$ **ii** $a = 48t^2 - \frac{2}{t^3}$
b i $v = 2t^2 - \frac{2}{t^3}$ **ii** $a = 4t + \frac{6}{t^4}$
c i $v = 18t^2 + 30t - 2$ **ii** $a = 36t + 30$
d i $v = \frac{9t^2}{2} - 2t - \frac{5}{2t^2}$ **ii** $a = 9t - 2 + \frac{5}{t^3}$

2 a $46\,\text{m s}^{-1}$ **b** $24\,\text{m s}^{-2}$

3 $7\,\text{m s}^{-2}$ in the direction of x decreasing.

4 6.75 m

5 a $k = 4$ **b** $a = -4\,\text{m s}^{-2}$

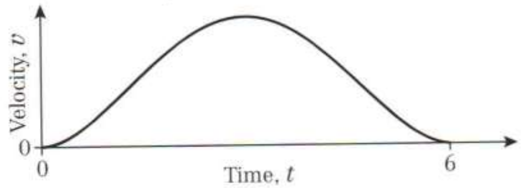
6 1.7 cm

Exercise 11C

1 a 0.25 s
b 4.54 m
c $v = -1.88\,\text{m s}^{-1}$

2 a If $t = 4$, $s = 4(4^3) - 4^4 = 0$
b Since $t \geqslant 0$, t^3 is always positive.
Since $t \leqslant 4$, $4 - t$ is always non-negative.
c 27 m

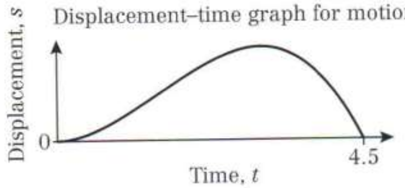
3 a Velocity–time graph for motion of P



b $v = 81\,\text{m s}^{-1}$ when $t = 3$ s

4 a Discriminant of $2t^2 - 3t + 5$ is <0, so no solutions for $v = 0$
b $3.88\,\text{m s}^{-1}$ (3 s.f.)

5 a Displacement–time graph for motion of P



b s is a distance so cannot be negative.
c 13.5 m **d** $9\,\text{m s}^{-2}$

6 Max distance is when $\frac{\text{d}s}{\text{d}t} = 3.6 + 3.52t - 0.06t^2 = 0$, so $t = 59.7$ (3 s.f.)
∴ Max distance = 2.23 km (3 s.f.), so the train never reaches the end of the track.

Exercise 11D

1 a $s = t^3 - t$ **b** $s = \frac{t^4}{2} - \frac{t^3}{2}$ **c** $s = \frac{4}{3}t^{\frac{3}{2}} + \frac{4t^3}{3}$

2 a $v = 4t^2 - \frac{2t^3}{3}$ **b** $v = 6t + \frac{t^3}{9}$

3 12 m

4 a $v = 6 + 16t - t^2$ **b** -6

5 42.9 m (3 s.f.)

6 12.375 m

7 a $10\frac{2}{3}$ **b** 13 m

8 $t = \frac{3}{2}$ and $t = 5$

9 a $t = 1$ and $t = 5$ **b** 6 m

10 $T = 1.5\,\text{s}$

11 **a** $v = \frac{t^2}{2} - 3t + 4$ **b** $t = 2$ and $t = 4$ **c** $\frac{2}{3}\,\text{m}$

12 **a** $86\,\text{m}$ **b** $60\,\text{m}\,\text{s}^{-1}$

Challenge

$\frac{200}{3}\,\text{m}$

Exercise 11E

1 $v = \int a\,dt = at + c$
$a \times 0 + c = 0 \Rightarrow c = 0 \Rightarrow v = at$
$s = \int v\,dt = \int at\,dt = \frac{1}{2}at^2 + k$
$\frac{1}{2}a \times 0^2 + k = x \Rightarrow k = x$
so $s = \frac{1}{2}at^2 + x$

2 **a** $a = 5$, $v = \int 5\,dt = 5t + c$; when $t = 0$, $u = 12$ so $c = 12$, $v = 12 + 5t$
b $s = \int 12 + 5t\,dt = 12t + \frac{5t^2}{2} + d$, when $t = 0$, $s = 7$ so $d = 7$, $s = 12t + 2.5t^2 + 7$

3 $v = \frac{ds}{dt} = u + at$; $\frac{dv}{dt} = a$ so constant acceleration a

4 **A** $a = 4 - 6t$, not constant
B $a = 0$. no acceleration
C $a = \frac{1}{2}$, constant
D $a = -\frac{12}{t^4}$ not constant
E $v = 0$, particle stationary

5 **a** $4\,\text{m}\,\text{s}^{-2}$ **b** $p = 2, q = 5, r = 0$

6 **a** $680\,\text{m}$
b $\frac{ds}{dt} = 25 - 0.4t \Rightarrow \frac{d^2s}{dt^2} = -0.4 \therefore a$ is constant
c $420\,\text{m}$ from A

Mixed exercise 11

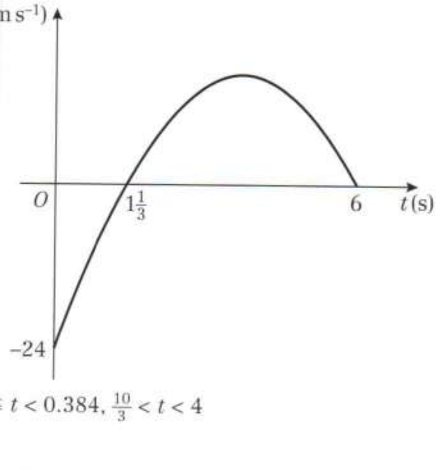
1 **a** $t = 5$
b $37.5\,\text{m}$

2 **a** $30\,\text{m}\,\text{s}^{-2}$
b $75\,\text{m}$

3 **a** Displacement $= 8t + t^2 - \frac{t^3}{3}$
b Max displacement when $t = 4$, $s = 26\frac{2}{3}\,\text{m}$, which is less than 30 m so P does not reach B.
c $t = 6.62\,\text{s}$
d $53\frac{1}{3}\,\text{m}$

4 **a** $\frac{32}{3}\,\text{m}\,\text{s}^{-1}$ **b** $\frac{40}{3}\,\text{m}$

5 **a** $(-3t^2 + 22t - 24)\,\text{m}\,\text{s}^{-1}$ **b** $t = \frac{4}{3}$ and $t = 6$
c $t = \frac{11}{3}$
d



e $0 \leqslant t < 0.384$, $\frac{10}{3} < t < 4$

6 **a** $t = \frac{5}{3}$ and $t = 2$ **b** $13\,\text{m}\,\text{s}^{-2}$ **c** $\frac{433}{27}\,\text{m}$

7 **a** $v = \frac{t^4}{2} - 4t^2 + 6$ **b** $s = \frac{t^5}{10} - \frac{4t^3}{3} + 6t$
c $t = \sqrt{2}$ and $t = \sqrt{6}$

8 max $= 8.64\,\text{m}$, min $= 1.14\,\text{m}$

9 $a = 1500$, $b = 800$, $c = -16$

10 **a** $v = \int 20 - 6t\,dt = 20t - 3t^2 + c$
At $t = 0$, $v = 7$ so $c = 7$ and $v = 7 + 20t - 3t^2$
b The greatest speed is $40\frac{1}{3}\,\text{m}\,\text{s}^{-1}$
c $196\,\text{m}$

11 $v = \int k(7 - t^2)dt \Rightarrow v = k\left(7t - \frac{t^3}{3}\right) + c$
$t = 0, v = 0 \therefore c = 0$; $t = 3, v = 6 \therefore k = \frac{1}{2}$
$v = \frac{7}{2}t - \frac{t^3}{6}$
$s = \int v\,dt = \int\left(\frac{7}{2}t - \frac{t^3}{6}\right)dt = \frac{7t^2}{4} - \frac{t^4}{24} + c$
$t = 0, s = 0 \therefore c = 0$
$s = \frac{7t^2}{4} - \frac{t^4}{24} = \frac{1}{24}t^2(42 - t^2)$

12 **a** Time cannot be negative so $t \geqslant 0$
at $t = 5$ $s = 0$ so mouse has returned to its hole.
b $39.1\,\text{m}$

13 **a** Mass is not constant as fuel is used.
Gravity is not constant so weight not constant.
Thrust may not be constant.
b $v = (1.69 \times 10^{-7})\,t^4 - (1.33 \times 10^{-4})\,t^3 + 0.0525\,t^2 + 0.859\,t + 273\,\text{m}\,\text{s}^{-1}$
c $v = 5990\,\text{m}\,\text{s}^{-1}$
d 510 seconds (2 s.f.) after launch

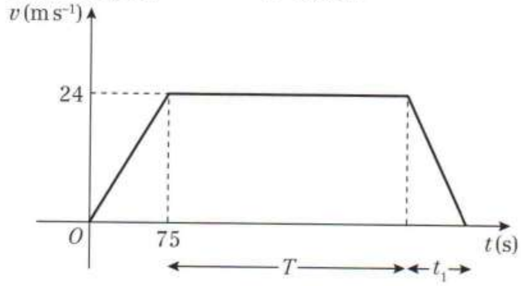
Challenge

1 $32.75\,\text{m}$
2 $91\,\text{m}\,\text{s}^{-1}$

Review exercise 2

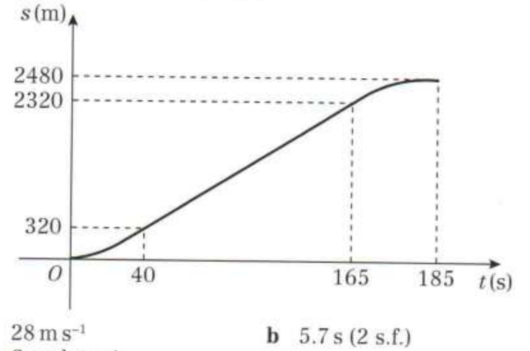
1 **a** Constant acceleration
b Constant speed **c** $30.5\,\text{m}$

2 **a**



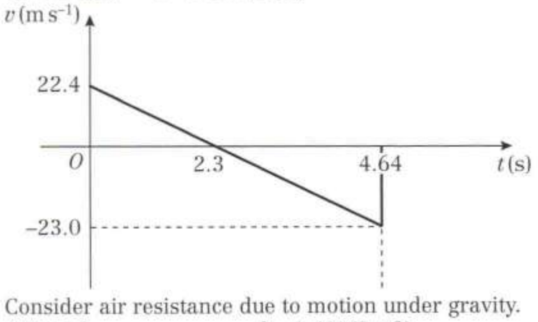
b $0.48\,\text{m}\,\text{s}^{-2}$ **c** $T = 250$ **d** $375\,\text{s}$

3 **a** $185\,\text{s}$ **b** $2480\,\text{m}$
c



4 **a** $28\,\text{m}\,\text{s}^{-1}$ **b** $5.7\,\text{s}$ (2 s.f.)

5 $t = 2$ and $t = 4$

6 $q = \sqrt{10}$ and $p = \sqrt{30}$
7 $66\frac{2}{3}$ m
8 a $0.693\,\text{m s}^{-2}$ (3 s.f.) b 7430 N (3 s.f.)
 c i Rotational forces and air resistance can be ignored.
  ii The tension is the same at both ends and its mass can be ignored.
9 a Ball will momentarily be at rest 25.6 m above A.
 $0^2 = u^2 + 2 \times (-9.8) \times 25.6$, $u = 22.4$
 b 4.64 (3 s.f.) c 6380 (3 s.f.)
 d


 e Consider air resistance due to motion under gravity.
10 a $4.2\,\text{m s}^{-2}$ b 3.4 N (2 s.f.)
 c $2.9\,\text{m s}^{-1}$ (2 s.f.) d 0.69 s (2 s.f.)
 e i String has negligible weight.
  ii Tension in string is constant i.e. same at A and B.
11 a 2.9 N (2 s.f.) b $4.9\,\text{m s}^{-2}$ c 0.21 s (2 s.f.)
 d Same acceleration for P and Q.
12 a i 1050 N ii 390 N
 b $3\,\text{m s}^{-2}$
13 a 8697 N b 351 N c 507 N
14 a 63°
 b $2 + \lambda = k$ (1) and $3 + \mu = 2k$ (2)
 $2 \times (1) = (2)$ so $4 + 2\lambda = 3 + \mu$ so $2\lambda - \mu + 1 = 0$
 c 4.47 (3 s.f.)
15 a 17.5 (1 d.p.)
 b 66°
 c $P = 3\mathbf{i} + 12\mathbf{j}$
 $Q = 4\mathbf{i} + 4\mathbf{j}$
16 6 s
17 a $4.5\,\text{m s}^{-1}$ b 4.5 s
18 a $t = 1$ and $t = \frac{5}{3}$ b $16\,\text{m s}^{-2}$ c 4 m
19 a $6 - 3t^{\frac{1}{2}}$ b $3t^2 - \frac{4}{5}t^{\frac{5}{2}}$

Challenge

1 $t_1 = 62.2$ s, $t_2 = 311.1$ s, $t_3 = 46.7$ s (3 s.f.)
 Distance = 20.6 km (3 s.f.)
2 a $a = 7.4\,\text{m s}^{-2}$ b 39 N
 c 13 N d 55 N (2 s.f.)
 e Acceleration is the same for objects connected by a taut inextensible string.

Practice paper

1 a 0.15
 b $P(B) \times P(M) = 0.1575$ so the events are not independent.
2 a Continuous – measured variable can take any value
 b 14.01, 1.36 (3 s.f.)
 c Increase – value higher than current mean
 d Clare could select random days in September. She could include data from other UK locations for September 2015.
3 a 0.2
 b 0.65
 c i 0.1757 ii 0.0260
4 a Test statistic is the number of plates that are flawed.
 H_0: $p = 0.3$, H_1: $p < 0.3$
 b 0, 1, 2 c 3.55%
 d 1 falls into the critical region therefore there is evidence to support the claim.
5 a Increase in energy released for each degree of temperature.
 b Value of h is a long way from the range of the experimental data so it would not be sensible – extrapolation.
 c The regression line should only be used to predict a value of e given h so it would not be sensible.
6 0.87 (2 d.p.)
7 a $0.75\,\text{m s}^{-2}$ b 845 N
 c Same acceleration for car and trailer
8 a $a = 3\mathbf{i} - \mathbf{j}\,\text{m s}^{-2}$
 b 18.4° below
 c $\sqrt{10}\,\text{m s}^{-2}$
9 a $24.5\,\text{m s}^{-1}$ b 30.625 m
 c $\frac{5}{7}$ s and $\frac{30}{7}$ s
10 $\frac{153}{16}$ m

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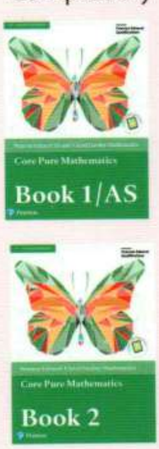

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