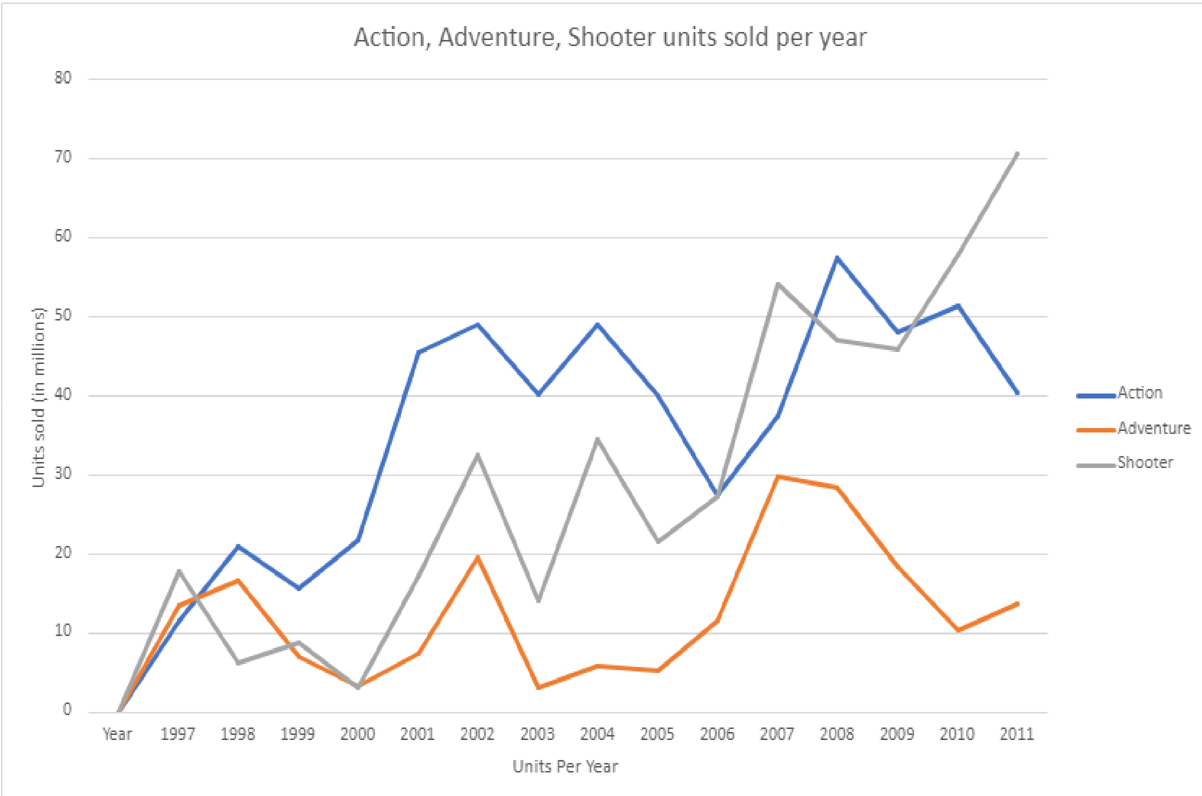
<u>Part A</u>

Question 1.



I started by highlighting the data provided in excel and then clicked on insert, then insert line chart, after that I edited it by right clicking on the table and going on format then from format I clicked on horizontal and vertical for both I turned on axis title and I simply typed in the titles for both axis.

Analyzing the graph, the trends in the three genres tell a different story. Action games have gone through an inconsistent sales pattern, that has a very noticeable contrast from year to year, but there is no clear seasonality is currently present this could be due to the annual data points. The action genre saw a major decline in 2004 and an increase in 2008 where it peaked, suggesting a possible correlation between market events and the impact of a specific successful game released during that time.

Moving to adventure games, the graph indicates that there is volatility, labelled by sharp increases and decreases in sales. A notable peak occurred around 2000, followed by a decrease and then later an increase in 2010. This irregular pattern indicates the influence of titles that have been hits and that captivate the market in their release years. However, a consistent long-term trend remains evasive, this could be due to the timing of when adventure games were released.

Shooter games, on the contrary shows a clear upward trend, particularly from 2007 and onwards, this indicates a surge in the genre's popularity or maybe the gaming era of advancement for example multiplayer gameplay has become a very popular thing in the gaming industry. This genre doesn't show vital seasonal changes, but it does show steady growth, which is likely to be reinforced by popular franchises like call of duty who have a dedicated fan base which has helped them to maintain their popularity.

Question 2

Naïve Method:

FORMULA: F(t+1) = A(t)

For Naïve forecasting, the forecast for any given year is equal to the actual sales of the previous year. To forecast the year 1998, I had to use the actual sales from 1997, then I had to repeat this step for each upcoming year, forecasting the next year's sales as the current year's actual sales. F(1998) = A(1997) = 17.92 ,F(2012) = A(2011) = 70.66.**Mean Squared Error (MSE)** Algebraic Formula: MSE = (1/n) * Σ [(A(t) - F(t))^2]. I subtracted the forecast sales from the actual sales for each year then squared the result of each subtraction after that I then summed all the squared results, then divided the sum by the number of data points (n), which is the number of years forecasted data (excluding the base year). Squaring each forecast error and summing for MSE: MSE = (1/n) * (134.096 + 194.34 + ... + 161.29) This is a summation of all squared forecast errors.

I then added up all the individual squared errors that I calculated in the squared forecast error column. This sum is then divided by the total number of years (n) to arrive at the MSE. The provided MSE value in my spreadsheet is 189.423, this is the average of the squared forecast errors. **Mean Absolute Deviation (MAD),** Algebraic Formula: MAD = (1/n) * Σ |A(t) - F(t)|. I subtracted the forecasted sales from the actual sales for each year to find the forecast error, I then took the absolute value of each forecast error and summed all the absolute values and divided them by the number of data points(n). Summing absolute errors for MAD: MAD = (1/n) * (11.58 + 5.77 + ... + 12.7) summation of all absolute forecast errors.

By adding up all the values in the 'absolute forecast error' column and then dividing by the number of data points, I get the MAD, which measures the average size of the forecast errors. In the spreadsheet, MAD is provided as 11.923, representing the average magnitude of the forecast errors. **Mean Absolute Percentage Error (MAPE),** Algebraic Formula: MAPE = (100/n) * Σ [|(A(t) - F(t))/A(t)|]. I calculated the absolute value of the percentage error for each year by dividing the absolute forecast error by the actual sales and multiplying by 100 and then summing the percentage errors and finally dividing the number of data points (n). Calculating percentages and summing for MAPE: MAPE = (100/n) * (1.826 + ... + 0.180) summation of all 'Forecast error/Actual' percentages. I Multiplied the sum of the 'Forecast error/Actual' column values by 100 and then I divided by the total number of forecast points to calculate the MAPE. The spreadsheet shows a MAPE of 64.461, this shows that the percentage of the error is relative to the actual sales figures.

Years	Shooter units sold (in millions)(At)	Forecast Naive Method(Ft)	*Forecast error*	*squared forecast error*		*absolute forecast error*		*|Forecast error/Actual|*
1997	17.92							
1998	6.34	17.92	-11.58	134.096		11.58		1.826
1999	8.89	6.34	2.55	6.503		2.55		0.287
2000	3.12	8.89	-5.77	33.293		5.77		1.849
2001	17.28	3.12	14.16	200.506		14.16		0.819
2002	32.49	17.28	15.21	231.344		15.21		0.468
2003	14.11	32.49	-18.38	337.824		18.38		1.303
2004	34.59	14.11	20.48	419.430		20.48		0.592
2005	21.51	34.59	-13.08	171.086		13.08		0.608
2006	27.19	21.51	5.68	32.262		5.68		0.209
2007	54.16	27.19	26.97	727.381		26.97		0.498
2008	47.13	54.16	-7.03	49.421		7.03		0.149
2009	45.88	47.13	-1.25	1.563		1.25		0.027
2010	57.96	45.88	12.08	145.926		12.08		0.208
2011	70.66	57.96	12.7	161.290		12.7		0.180
2012		70.66	MSE	189.423	MAD	11.923	MAPE	64.461

Three-Period Moving Average (MA3)

Standard Algebraic Formula: MA(t+1) = (A(t) + A(t-1) + A(t-2)) / 3. The three-period moving average forecast is calculated by taking the average of the actual sales figures from the preceding years. I firstly identified the actual sales figures for the three years prior to the year for which the forecast is being based upon. Then I added these three figures together and divided the sum by 3 to get the average. The forecasted sales figure for the next year is the resulting average. MA(2012) = (A(2011) + A(2010) + A(2009)) / 3, MA(2012) = (70.66 + 57.96 + 45.88) / 3, MA(2012) = 58.17 million units. Here you can see A(2011), A(2010), and A(2009) are the actual sales figures for 2011, 2010, and 2009, respectively, from the dataset. The calculated forecast for 2012 (MA(2012)) is the average of these sales figures. **Mean Squared Error (MSE) for MA3,** Algebraic Formula: MSE = (1/n) * Σ [(A(t) - MA(t))^2]. For each year I subtracted the MA3 forecast from the actual sales to get the return of the forecast error then square each forecast error then I add all the squared forecast errors together, then divide the total by the number of the forecasted years to find the MSE which is 191.857. MSE = (1/n) * (Sum of 'squared forecast error' column).

Mean Absolute Deviation (MAD) for MA3, Algebraic Formula: MAD = (1/n) * Σ |A(t) - MA(t)|. I calculated the absolute value of each forecast error, then summed the absolute values and divided by the number of forecasted years to return the MAD which is 11.6. MAD = (1/n) * (Sum of 'absolute forecast error' column). **Mean Absolute Percentage Error (MAPE) for MA3,** Algebraic Formula: MAPE = (100/n) * Σ [|(A(t) - MA(t))/A(t)|]. For each year I divided the absolute forecast error by the actual sales to find the percentage error then I multiplied each percentage error by 100 and then added all the percentage errors together and finally divided the number of forecasted years to calculate the MAPE which is 51.553. MAPE = (100/n) * (Sum of 'Forecast error/Actual' column values)

Years	*Shooter units sold (in millions)*	*MA(3)*	*Forecast error*	*squared forecast error*		*absolute forecast error*		*|Forecast error/Actual|*
1997	17.92							
1998	6.34							
1999	8.89							
2000	3.12	11.1	-7.9	62.885		7.9		2.542
2001	17.28	6.1	11.2	124.620		11.2		0.646
2002	32.49	9.8	22.7	516.501		22.7		0.699
2003	14.11	17.6	-3.5	12.390		3.5		0.249
2004	34.59	21.3	13.3	176.801		13.3		0.384
2005	21.51	27.1	-5.6	30.840		5.6		0.258
2006	27.19	23.4	3.8	14.339		3.8		0.139
2007	54.16	27.8	26.4	696.784		26.4		0.487
2008	47.13	34.3	12.8	164.951		12.8		0.273
2009	45.88	42.8	3.1	9.323		3.1		0.067
2010	57.96	49.1	8.9	79.269		8.9		0.154
2011	70.66	50.3	20.3	413.580		20.3		0.288
2012		58.2	MSE	191.857	MAD	11.6	MAPE	51.55309879

Exponential Smoothing

FORMULA : F(t+1) = α * A(t) + (1 - α) * F(t). The first set of data in the initial forecast for, F(1997) is said to be equal to the actual sales of 1997, which we can see is 17.92 million in units since there isn't a prior forecast available for the year before which is the first year in the dataset. For the year following 1997, I calculated the forecast using the smoothing constant α which is 0.4 and the actual sales figure from the current year, A(t), along with the forecast from the year before, F(t). For example, the calculation for the year 1998 using the actual data from sales from 1997 and the smoothing constant 0.4 would be: F(1998) = 0.4 * A(1997) + 0.6 * F(1997), F(1998) = 0.4 * 17.92

+ 0.6 * 17.92, F(1998) = 7.168 + 10.752, F(1998) = 17.92 (since the forecast for the first year is the same as the actual). I continue this process for each upcoming year. For 1999, I took the actual sales from 1998 which is 6.34 million units and the forecasted sales for 1998 which is only the actual sales from 1997 for this calculation, to calculate the forecast for 1999: F(1999) = 0.4 * A(1998) + 0.6 * F(1998), F(1999) = 0.4 * 6.34 + 0.6 * 17.92, F(1999) = 2.536 + 10.752, F(1999) = 13.288 (rounded to three decimal places). For the last year in the dataset, 2012, I would simply select the actual sales from 2011 and the forecast for 2011, as calculated via exponential smoothing. F(2012) = 0.4 * A(2011) + 0.6 * F(2011),F(2012) = 0.4 * 70.66 + 0.6 * 48.88 (assuming F(2011) is 48.88 from my spreadsheet), F(2012) = 28.264 + 29.328, F(2012) = 57.592. The forecast for 2012 is 57.592 million units, using the exponential smoothing forecast method with the designated values from the spreadsheet. **Mean Squared Error (MSE**). Algebraic Formula: MSE = (1/n) * Σ [(A(t) - F(t))^2]. I Calculated the squared differences between the actual sales (A(t)) and the forecasted sales (F(t)) for each year. Then I Sumed of all the squared differences after that I divided the sum by the number of data points (n), which is the number of years with both actual sales and forecasts. MSE = (1/15) * (Σ of 'squared forecast error' column), MSE = (1/15) * (134.096 + ... + 474.34) I Continued summing up all the squared errors. After summing all the squared errors from the column in the spreadsheet, I would divide by 14, since there are 14 years from 1997 to 2011 to calculate the average which is 198.59.

Mean Absolute Deviation (MAD), Algebraic Formula: MAD = (1/n) * Σ |A(t) - F(t)|. I Calculated the absolute differences between the actual and forecasted sales for each year. Then Sumed all the absolute differences and finally divide the sum by the number of data points (n). MAD = (1/15) * (Σ of 'absolute forecast error' column), MAD = (1/15) * (11.58 + ... + 21.78) I Continued summing up all the absolute errors. I then add up all the values in the 'absolute forecast error' column and divide by 14. The resulting value is the MAD in my forecast which is 11.842. **Mean Absolute Percentage Error (MAPE),** Algebraic Formula: MAPE = (100/n) * Σ [|(A(t) - F(t))/A(t)|]. I calculated the absolute percentage error for each year by taking the absolute difference between actual and forecasted sales, dividing by the actual sales, and then multiplying by 100 to get a percentage. Then I Sumed all the absolute percentage errors, then finally divided the sum by the number of data points (n) and got 62.989. MAPE = (100/15) * (Σ of 'Forecast error/Actual' column), MAPE = (100/15) * (1.825 + ... + 0.672) I Continued summing up all the percentage errors. Lastly, I multiplied the sum of the 'Forecast error/Actual' column values by 100 and divide by 14 to get the MAPE which is 62.989.

Years	*Shooter units sold (in millions)*	*Exponetial Smoothing*	*Forecast error*	*squared forecast error*		*absolute forecast error*		*|Forecast error/Actual|*
1997	17.92							
1998	6.34	17.92	-11.6	134.10		11.58		1.826
1999	8.89	13.29	-4.4	19.34		4.40		0.495
2000	3.12	11.53	-8.4	70.71		8.41		2.695
2001	17.28	8.17	9.1	83.08		9.11		0.527
2002	32.49	11.81	20.7	427.61		20.68		0.636
2003	14.11	20.08	-6.0	35.67		5.97		0.423
2004	34.59	17.69	16.9	285.49		16.90		0.488
2005	21.51	24.45	-2.9	8.66		2.94		0.137
2006	27.19	23.28	3.9	15.32		3.91		0.144
2007	54.16	24.84	29.3	859.59		29.32		0.541
2008	47.13	36.57	10.6	111.54		10.56		0.224
2009	45.88	40.79	5.1	25.88		5.09		0.111
2010	57.96	42.83	15.1	228.98		15.13		0.261
2011	70.66	48.88	21.8	474.34		21.78		0.308
2012		57.59	MSE	198.59	MAD	11.842	MAPE	62.989
a(alpha)	0.4							
1- a(alpha	0.6							

Question 3

Based off the error metrics for the 3 techniques: **Analysis of Error Metrics:** Naïve Method has the following metrics: MSE: 189.423, MAD: 11.923, MAPE: 64.461. Three-Period Moving Average (MA3) shows: MSE: 191.857, MAD: 11.6, MAPE: 51.553. Exponential Smoothing presents: MSE: 198.59, MAD: 11.842, MAPE: 62.989

The values with the lower MSE shows a model that has a closer fit to the actual data as it has a lower variance of forecast errors. Here, the Naive method has the lowest MSE, this suggests that there is less variability in its forecast errors. The MAD measures the average level of errors between the forecasts and actual sales. The three-period moving average method has had the lowest MAD, which indicates that it commonly has the lowest forecast errors in terms of absolute difference. A lower MAPE indicates that the forecast errors are smaller when considering in relation to the actual sales figures. The three-period moving average has the lowest MAPE, this suggests that the forecast errors are the lowest which is relative to the scale of the actual sales.

Based on the error metrics that are provided, the Three-period moving average is the method which is highly recommended. Despite its MSE being slightly higher compared to the naive method, the three-period moving average has the smallest MAD and significantly lower MAPE. This indicates that not only does it offer forecasts with the lowest deviations from the actual sales on average (MAD) but also the best relative accurate (MAPE), making it more of a balanced choice for forecasting sales in the 'Shooter' genre. The naive method, whilst having the smallest MSE, has the highest MAPE, indicating that is percentage errors are related to the actual sales are the biggest, which can be very vital in decision-making scenarios when the error has more impact that the variance alone. In which the three-period moving average tends to have the best of both worlds in terms of consistency (MSE), average error level (MAD) and relative accuracy (MAPE), making it the more preferred model for the forecasting.

Question 4

The forecasting model that I would recommend would be estimated regression. This statistical method is used to model relationship between a dependent variable and one or more independent variables by placing a linear equation to viewed data. Ref: Montgomery, D.C., Peck, E.A., & Vining, G.G. (2012). "Introduction to Linear Regression Analysis". This book provides an in-depth understanding of regression analysis as a predictive modeling tool. The slope of the line 'b1' is calculated by determining the ratio of the variable 't'(time) and 'At'(observed values) to the variance of 't'. The formula for that is : b1 = (n * Σ(t * A_t) - (Σt * ΣA_t)) / (n * Σ(t^2) - (Σt)^2), 'n' is the number of observations., 'Σ(t * A_t)' is the sum of the product of time and observed values., 'Σt 'is the sum of the time periods., 'ΣA_t' is the sum of the observed values., 'Σ(t^2)' is the sum of the squares of the time periods.

The intercept 'b0' is representing the that crosses the Y-axis it is the point of the trend line when 't' equals zero. The Innercept is calculated using the average of the observed values 'Ā' and the average time ' t̄ 'minus the product of the slope and the average time. The formula is: b0 = Ā - b1 * t̄, Ā is the mean of the observed values., t̄ is the mean of the time periods., b1 is the slope from the previous calculation. Once b1 and b0 are known, the regression line can be described, I can forecast future points by substituting the time period t into the regression equation: Tt =b0 +b1 t . Where Tt is the forecasted value for time period t. This method assumes a linear relationship between the time period and the observed values. To compare the estimated regression forecasting with the other methods, I would forecast sales for a given time period using the regression model and then use error metrics like MSE, MAD, and MAPE for evaluation. For regression, use the formula: Ft =b0 +b1 * t ,where Ft is the forecast ,b0 is the y-intercept, b1 is the slope, and t is the time period. To calculate the forecast for 2012 (t = 16) and compare the error metrics against those from Naïve, Moving Average, and Exponential Smoothing. The method with the lowest error metrics is typically preferred, with the choice also depending on the data's trend and pattern characteristics. Regression is particularly useful when the impact of different variables on sales is of interest. Each technique has a distinct advantage depending on the forecasting context. Regression is very good at capturing overall trends and providing an insight for long-term forecasting by implementing a full range of historical data. This method is more robust to short-term fluctuations, by giving more of a stable prediction which is very useful for strategizing and comprehending long-term patterns.

	Shooter units sold (in millions) (A_t)	*year (t)*	*tA_t*	*t_2*
	17.92	1	17.92	1
	6.34	2	12.68	4
	8.89	3	26.67	9
	3.12	4	12.48	16
	17.28	5	86.4	25
	32.49	6	194.94	36
	14.11	7	98.77	49
	34.59	8	276.72	64
	21.51	9	193.59	81
	27.19	10	271.9	100
	54.16	11	595.76	121
	47.13	12	565.56	144
	45.88	13	596.44	169
	57.96	14	811.44	196
	70.66	15	1059.9	225
Totals	*459.23*	*120*	*4821.17*	*1240*
Averages	*30.61533333*	*8*		

n =	*15*
b1 =	*4.098*
b0 =	*-2.166*

Question 5

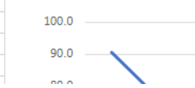
Y=b0 +b1 X

The regression analysis shows that the shooter's average review score has a positive correlation with global video games sales. B1 = 0.277 which is the slope where it clearly indicates that as the average scire review increases, then the sales are then estimated to increase as well. But the R-squared value of 0.0676 shows that only around 6.67% of the variation in sales can be included to the review score. This makes it be known that even though there is a significant relationship, the review score is not the sole decider of sales. For forecasting purposes, it is feasible to implement the average review into a sales forecast model. Between the average review score and the global sales can be described by this linear regression equation Y = 78.691 + 0.277X. The least squares method has given a straight-line approximation that is able to make predictions based on the average review score. Y = 78.691 + 0.277X, this allows me to make an estimate of the expected sales from the review score. This analysis essentially shows the estimation of shooter sales based on its average review score, for example if the shooter video game has an average score of 80.903.

n =	15
b1 =	4.098
b0 =	-2.166

	Avg Review Score (At)	year (t)	tAt	t2
	90.8	1	90.7775	1
	74.4	2	148.85	4
	71.2	3	213.7275	9
	82.5	4	330	16
	79.4	5	397.0333333	25
	76.8	6	460.696	36
	80.0	7	560.18	49
	79.8	8	638.2447059	64
	83.6	9	752.3446154	81
	80.2	10	802.3583333	100
	84.9	11	934.34	121
	80.5	12	966.1527273	144
	84.7	13	1101.36	169
	79.3	14	1110.471765	196
	85.3	15	1279.288636	225
Totals	1213.548	120	9785.825	1240
Averages	80.903	8		

n =	15
b1 =	0.277
b0 =	78.691



tAt	t2
90.7775	1
148.85	4
213.7275	9
330	16
397.0333333	25
460.696	36
560.18	49
638.2447059	64
752.3446154	81
802.3583333	100
934.34	121
966.1527273	144
1101.36	169
1110.471765	196
1279.288636	225
9785.825	1240

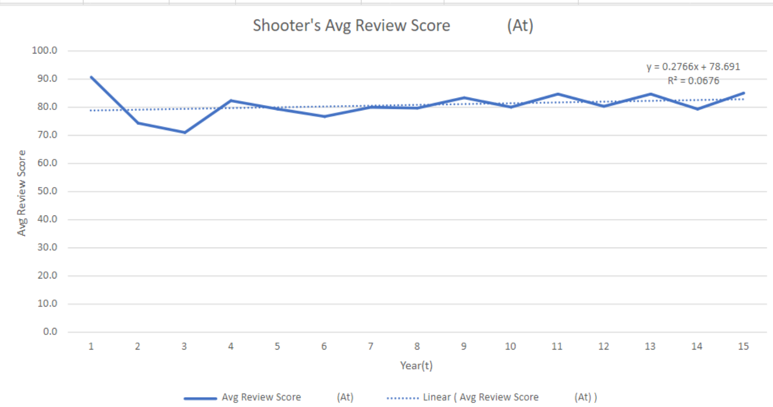
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.689
R Square	0.475
Adjusted R Square	0.431
Standard Error	3.050
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	100.883	100.883	10.841	0.006
Residual	12	111.666	9.305		
Total	13	212.548			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	74.538	1.903	39.176	4.93E-14	70.392	78.683	70.392	78.683
1	0.666	0.202	3.293	0.006	0.225	1.107	0.225	1.107



Part B

Question 1

I used the cumulative probability method to assign intervals to random numbers, this allows the time intervals for the simulation between customer calls based on their probability distribution. Each time interval has a matching probability, with the intervals starting at zero and then extending to 1, split in accordance with the cumulative probability of each call duration. For example, provided that the probability for a 5-minute call is 0.10, I allocate random numbers from 0 to 0.10 for this interval. The following interval, an 8-minute call, with a probability of 0.20, taking the next range from 0.10 to 0.30, I added the previous upper limit to the current probability. This specific pattern progresses with the 10-minute interval occupying the range from 0.30 to 0.70, and the 12-minuute interval covers the final range from 0.70 to 1.00.

		Intervals of random numbers	
Calls (min)	Probability	Lower limit	Upper limit
5	0.1	0	0.1
8	0.2	0.1	0.3
10	0.4	0.3	0.7
12	0.3	0.7	1

Question 2

This process has involved mapping the random numbers to a time interval that is based on the cumulative probability distribution. Given that I've established intervals for the times of 5, 8, 10 and 12 minutes based on the probabilities. I used the vlookup and did =vlookup(0.83459,and highlighted lower limit, upper limit and calls(min) then put a comma and 3 to highlight the 3rd row , for example it had given me the value for day 3 as 12 as it sits in-between the lower and upper limit of 12, I applied the same thing for all mappings.

F	G	H
Days	Random Numbers	Calls (min)
1	0.53933	10
2	0.71344	12
3	0.83459	12
4	0.37075	10
5	0.00997	5
6	0.31444	10
7	0.48636	10
8	0.12296	8
9	0.09736	5
10	0.28647	8
	Total	90

Question 3

I firstly started off by inputting the given average service time of 10 for all columns. I then moved on by adding the given random numbers from the previous question into the interarrival time. Focusing on the first customer I put the **arrival time = to interarrival time which is 0.539**. Similarly, the start time is equal to the arrival time making it

0.539 as. For the waiting time I had to do **start time – arrival time(0.539-0.539)** which gave me 0 for the first caller. For the completion time I did **start time + service time(0.539 + 10)** which gave me 10.539. For the time in the system I simply did **completion time – arrival time (10.539 - 0.539)** which in return gave me 10. Moving onto the second customer I had to be slightly more careful with the calculations, so for caller 2 in arrival time I did arrival time from the previous caller so caller 1, which is 0.539 and then added the interarrival time from caller 2 so essentially did **Arrival time(caller1) + interarrival time (caller2) which is 0.539 + 0.713** which gave me 1.252 for caller 2 arrival time. Caller 2 service start time, to determine this I did if the arrival time > completion time of the previous customer (caller1), then the start time would be the arrival time of caller 2 otherwise if that is not the case then the start time would be the completion time. Which leaves me with 10.539. To calculate the waiting time I did **start time – arrival time(10.539 - 1.252)** which in return gives me 9.287 for waiting time. For completion time I did **start time + service time (10.539 + 10)** which give me 20.539. And finally for time in the system I did **completion time – arrival(20.539 - 1.252)** which gave me 19.287 . Having done these I simply dragged it down to get the rest of the values and then calculated the average of time spent by caller which I did **(19.287 + 28.452 + 38.081 + 48.071 + 57.757 + 67.271 + 77.148 + 87.051 + 96.765)/9 = 52.9883.** The average time spent by callers was 52.9883.

Callers	Interarrival time	Arrival time	Service start time	Waiting time	Service time	Completion time	Time in system
1	0.539	0.539	0.539	0	10	10.539	10
2	0.713	1.252	10.539	9.287	10	20.539	19.287
3	0.835	2.087	20.539	18.452	10	30.539	28.452
4	0.371	2.458	30.539	28.081	10	40.539	38.081
5	0.01	2.468	40.539	38.071	10	50.539	48.071
6	0.314	2.782	50.539	47.757	10	60.539	57.757
7	0.486	3.268	60.539	57.271	10	70.539	67.271
8	0.123	3.391	70.539	67.148	10	80.539	77.148
9	0.097	3.488	80.539	77.051	10	90.539	87.051
10	0.286	3.774	90.539	86.765	10	100.539	96.765
						Average time spent by callers	52.9883

Question 4

I firstly started off by inputting the service time by calculating it by doing service time = (random number,mean, standard deviation). I then moved on by adding the given random numbers from the previous question into the interarrival time. Focusing on the first customer I calculated the interarrival time by using the formula –9*logarithm*(random number). Similarly, the start time is equal to the arrival time. For the waiting time I had to do **start time – arrival time**. For the completion time I did **start time + service time**. For the time in the system I simply did **completion time – arrival time**. Moving onto the second caller I had to be slightly more careful with the calculations, so for caller 2 in arrival time I did arrival time from the previous caller so caller 1, and then added the interarrival time from caller 2 so essentially did **Arrival time(caller1) + interarrival time (caller2)** for caller 2 arrival time. Caller 2 service start time, to determine this I did if the arrival time > completion time of the previous customer (caller1), then the start time would be the arrival time of caller 2 otherwise if that is not the case then the start time would be the completion time. Which leaves me with 10.539. To calculate the waiting time I did **start time – arrival time**. For completion time I did **start time + service time**. And finally for time in the system I did **completion time – arrival**. Having done these, I simply dragged it down to get the rest of the values.

Scenario 2:

Time spent in the system by each call is the sum of waiting time and the service time which encapsulates the whole duration of the caller's interactions within the system. For example, the first caller's arrival time is set at 13.460 minutes, this matches the interarrival time with no previous calls, leading to a no wait time and a service time which is equal to the arrival time. Following up from the service time of 13.299 minutes, the call ends at 26.759 minutes, signifying the total time in the system for that specific call. Reciprocally, by the 10th caller, there has been a sudden buildup of arrival times, this is credited to the increase of interarrival times. This leaves the question, should the representative be immediately available, the service for the last caller begins upon arrival, if we delete any wait time this would result in a total time in the system that corresponds to the service time.

Scenario 2							
Callers	Interarrival time	Arrival time	Service start time	Waiting time	Service time	Completion time	Time in system
1	73.559	73.559	73.559	0.000	5.746	79.304	5.746
2	3.662	77.221	79.304	2.083	3.577	82.881	5.660
3	5.654	82.875	82.881	0.006	2.556	85.437	2.562
4	2.072	84.947	85.437	0.490	2.943	88.380	3.433
5	5.194	90.141	90.141	0.000	8.927	99.068	8.927
6	1.025	91.166	99.068	7.902	6.753	105.821	14.655
7	3.984	95.149	105.821	10.671	7.827	113.648	18.498
8	0.584	95.734	113.648	17.914	7.412	121.060	25.326
9	3.749	99.483	121.060	21.577	10.842	131.902	32.420
10	12.097	111.580	131.902	20.322	7.607	139.509	27.929

Scenario 3:

This scenario involves two customer service representatives (REP1 AND REP 2), each call's timing is handled in a different process which is influenced by several variables that have interactions which helps to define the customer service experience. The interarrival time, shows the duration between the arrivals of sequential calls, which is independent from the calls that were previously completed. The arrival time gathers the interarrival times which indicates when each call enters the queue. As calls are taking place, they allocated to either REP1 or REP2 depending upon availability. The service start time for each representative is contingent due to their engagement. If a representative is currently free at an arrival of a call, then the service will begin immediately, this is mirrored back by the arrival time which equalizes the service time. But, if the representative (REP1) is occupied, the service for a new call will begin when the end time has been reached of the representative previous call. This end time is described in columns E and G for REP1 and REP2, this indicates that when representative finishes a call, calculated by adding a predetermined or randomly assigned service time to the service start time. Column H is where the waiting time is recorded, a calls time span remains unanswered when entering the system, which is directly derived from the representative's availability.

Scenario 3										
Callers	Interarrival time	Arrival time	Service start time(REP1)	End time(REP1)	Service start time (REP2)	Endtime(REP2)	Waiting time	Service time	Completion time	Time in system
1	3.884	3.884	3.884	15.778	3.884	15.778	0.000	11.894	15.778	11.894
2	2.125	6.010	15.778	25.689	6.010	15.920	9.769	9.910	25.689	19.679
3	12.417	18.427	25.689	34.134	18.427	26.872	7.262	8.445	34.134	15.707
4	9.087	27.514	34.134	46.714	27.514	40.094	6.620	12.579	46.714	19.199
5	10.262	37.776	46.714	55.186	37.776	46.249	8.938	8.473	55.186	17.410
6	4.538	42.314	55.186	67.313	42.314	54.441	12.872	12.127	67.313	25.000
7	14.989	57.303	67.313	72.838	57.303	62.828	10.010	5.525	72.838	15.535
8	8.212	65.515	72.838	86.194	65.515	78.871	7.322	13.356	86.194	20.678
9	3.034	68.549	86.194	99.322	68.549	81.678	17.644	13.128	99.322	30.772
10	4.898	73.447	99.322	101.915	73.447	76.040	25.875	2.593	101.915	28.468

Question 5

The statistics for scenario 2:Average Waiting Time: 66.211 minutes, Average Service Time: 8.027 minutes, Average, Completion Time: 474.466 minutes and Maximum Waiting Time: 121.572 minutes. The statistics for scenario 3 are: Average Waiting Time: 36.454 minutes, Average Service Time: 8.874 minutes, Average Completion Time: 479.346 minutes, Maximum Waiting Time: 101.201 minutes. How I calculated these statistics I simply calculated the average by adding all the values and dividing by how many there are and for the maximum waiting time I inputted the highest value. Comparing the two scenarios, we can already tell that scenario 3 outperforms scenario 2 across all metrics. Scenario 3 has a lower average waiting time, this is highly likely to translate to the customer satisfaction being improved. The average service time seems to be lower which shows higher efficiency in terms of handling calls done by representatives. Looking at the average completion time it is significantly lower, which indicates that the calls are being sorted in a more effective manner overall. The maximum waiting time is marginally lower in scenario 3, which shows that even the calls that have long waiting are not waiting as long as the callers waiting in scenario 2.

With the given improved performance of scenario three the recommendations I came up with could be:

Staff training: To reduce service times, an investment in training for staff members would be highly beneficial for them to be able to handle calls more effectively.

Peak time management: Being able to identify peak calling times and to make sure that it is fine for staff during those periods of time to maintain low waiting times.

Technology: Creating/implementing a call-routing type of technology would help immensely to distribute calls between representatives who are available.

Workforce Management: In scenario 3 we can see that it already includes 3 customer service representatives, they could monitor call patterns to make sure the level of staffing is applicable throughout the entire day and shifts can be adjusted when necessary.

Scenario 2	
Average Waiting Time	66.211
Average Service Time	8.027
Average Completion Time	474.466
Maximum Waiting Time	121.572

Scenario 3	
Average Waiting Time	36.454
Average Service Time	8.874
Average Completion Time	479.346
Maximum Waiting Time	101.201