BINOMIAL DISTRIBUTION

1) $n = 10$
$r = 0, 1$ [knock down]
$p = 1/6$ (knock down)
$q = 5/6$

P(knock down less than 2 hurdles)
$= P(0) + P(1)$
$= {}^{10}C_0 \left(\frac{1}{6}\right)^0 \left(\frac{5}{6}\right)^{10} + {}^{10}C_1 \left(\frac{1}{6}\right)^1 \left(\frac{5}{6}\right)^9$
$= 0.485$

2) (i) $n = 8$
$r = 2$ (getting 3)
$p = 1/6$ (— " —)
$q = 5/6$

P(getting 3 exactly twice)
$= P(2)$
$= {}^8C_2 \left(\frac{1}{6}\right)^2 \left(\frac{5}{6}\right)^6$
$= 0.260$

(ii) $n = 8$
$r = 7, 8$ (getting 3)
$p = \frac{1}{6}$ (— " —)
$q = 5/6$

P(getting 3 atleast 7 times)
$= P(7) + P(8)$
$= {}^8C_7 \left(\frac{1}{6}\right)^7 \left(\frac{5}{6}\right)^1 + {}^8C_8 \left(\frac{1}{6}\right)^8 \left(\frac{5}{6}\right)^0$
$= 2.441 \times 10^{-5}$

(iii) $n = 8$
$r = 1, 2, \ldots, 8$ (getting 3)
$p = 1/6$ (— " —)
$q = 5/6$

P(getting 3 atleast once)
$= P(1) + P(2) + \cdots + P(8)$
$= 1 - P(0)$
$= 1 - {}^8C_0 \left(\frac{1}{6}\right)^0 \left(\frac{5}{6}\right)^8$
$= 0.767$

3) $n = 7$
$r = 0, 1$ (defective)
$p = 0.1$ (— " —)
$q = 0.9$

P(Not more than 1 defective)
$= P(0) + P(1)$
$= {}^7C_0 (0.1)^0 (0.9)^7 + {}^7C_1 (0.1)^1 (0.9)^6$
$= 0.850$

4) i) $N = 100$
$n = 10$
$r = 7$ (heads)
$p = \frac{1}{2}$ (— " —)
$q = \frac{1}{2}$

P(7 heads & 3 tails)
$= {}^{10}C_7 \left(\frac{1}{2}\right)^7 \left(\frac{1}{2}\right)^3$
$= 0.1172$

No. of sets with 7 heads & 3 tails
$= N \times P$
$= 100 \times 0.1172$
$= 117.2$
$\cong 117$

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ii) $N = 100$
$n = 10$
$r = 7, 8, 9, 10$ (heads)
$p = \frac{1}{2}$ (—— " ——)
$q = \frac{1}{2}$

P(atleast 7 heads)
$= P(7) + P(8) + P(9) + P(10)$
$= {}^{10}C_7 \left(\frac{1}{2}\right)^7 \left(\frac{1}{2}\right)^3 + {}^{10}C_8 \left(\frac{1}{2}\right)^8 \left(\frac{1}{2}\right)^2$
$+ {}^{10}C_9 \left(\frac{1}{2}\right)^9 \left(\frac{1}{2}\right)^1 + {}^{10}C_{10} \left(\frac{1}{2}\right)^{10} \left(\frac{1}{2}\right)^0$
$= 0.1719$

No. of sets with atleast 7 heads
$= N \times P$
$= 100 \times 0.1719$
$= 171.9$
$\simeq 172$

5)(i) $N = 2000$
$n = 4$
$r = 1, 2, 3, 4$ (boy)
$p = \frac{1}{2}$ (boy)
$q = \frac{1}{2}$

P(atleast a boy) $= P(1) + P(2) + P(3) + P(4)$
$= {}^4C_1 \left(\frac{1}{2}\right)^1 \left(\frac{1}{2}\right)^3 + {}^4C_2 \left(\frac{1}{2}\right)^2 \left(\frac{1}{2}\right)^2$
$+ {}^4C_3 \left(\frac{1}{2}\right)^3 \left(\frac{1}{2}\right)^1 + {}^4C_4 \left(\frac{1}{2}\right)^4 \left(\frac{1}{2}\right)^0$
$= 0.9375$

No. of families with atleast a boy
$= N \times P$
$= 2000 \times 0.9375 = 1875$

ii) $N = 2000$
$n = 4$
$r = 1, 2$ (girl)
$p = \frac{1}{2}$ (girl)
$q = \frac{1}{2}$

P(1 or 2 girl) $= P(1) + P(2)$
$= {}^4C_1 \left(\frac{1}{2}\right)^1 \left(\frac{1}{2}\right)^3 + {}^4C_2 \left(\frac{1}{2}\right)^2 \left(\frac{1}{2}\right)^2$
$= 0.625$

No. of families with 1 or 2 girls
$= N \times P$
$= 2000 \times 0.625$
$= 1250$

iii) $N = 2000$
$n = 4$
$r = 0$ (girl)
$p = \frac{1}{2}$ (girl)
$q = \frac{1}{2}$

P(No girl) $= P(0)$
$= {}^4C_0 \left(\frac{1}{2}\right)^0 \left(\frac{1}{2}\right)^4$
$= 0.0625$

No. of families with 0 girl
$= N \times P$
$= 2000 \times 0.0625$
$= 125$

(iv) $N = 2000$ $n = 4$
$r = 2$ (boys)
$p = \frac{1}{2}$ (— " —) $q = \frac{1}{2}$

P(2 boys) $= P(2) = {}^4C_2 \left(\frac{1}{2}\right)^2 \left(\frac{1}{2}\right)^2$
$= 0.375$

No. of families with 2 boys
$= N \times P = 2000 \times 0.375$
$= 750$

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(3)

6) (i) $n = 6$
$r = 3, 4, 5, 6$ (busy)
$p = 1/15$ (busy)
$q = 14/15$

P(atleast 3 busy)
$= P(3) + P(4) + P(5) + P(6)$
$= {}^6C_3\left(\frac{1}{15}\right)^3\left(\frac{14}{15}\right)^3 + {}^6C_4\left(\frac{1}{15}\right)^4\left(\frac{14}{15}\right)^2$
$+ {}^6C_5\left(\frac{1}{15}\right)^5\left(\frac{14}{15}\right)^1 + {}^6C_6\left(\frac{1}{15}\right)^6\left(\frac{14}{15}\right)^0$
$= 5.084 \times 10^{-3}$

ii) $n = 6$
$r = 0, 1, 2, 3$ (busy)
$p = \frac{1}{15}$ (busy)
$q = \frac{14}{15}$

P(Not more than 3 busy)
$= P(0) + P(1) + P(2) + P(3)$
$= {}^6C_0\left(\frac{1}{15}\right)^0\left(\frac{14}{15}\right)^6 + {}^6C_1\left(\frac{1}{15}\right)^1\left(\frac{14}{15}\right)^5$
$+ {}^6C_2\left(\frac{1}{15}\right)^2\left(\frac{14}{15}\right)^4 + {}^6C_3\left(\frac{1}{15}\right)^3\left(\frac{14}{15}\right)^3$
$= 0.9997$

7) $n = 10$
$r = 7, 8, 9, 10$ (head)
$p = \frac{1}{2}$ (head)
$q = \frac{1}{2}$

P(atleast 7 heads) $= P(7) + \dots + P(10)$
$= {}^{10}C_7\left(\frac{1}{2}\right)^{10} + {}^{10}C_8\left(\frac{1}{2}\right)^{10} + {}^{10}C_9\left(\frac{1}{2}\right)^{10}$
$+ {}^{10}C_{10}\left(\frac{1}{2}\right)^{10}$
$= 0.1719$

8) $P(A \text{ win}) = \frac{3}{5}$
$P(B \text{ win}) = \frac{2}{5}$
$n = 5$
$r = 3, 4, 5$ (A's win)
$p = \frac{3}{5}$ (— " —)
$q = 1 - p = \frac{2}{5}$

P(A win atleast 3 out of 5)
$= P(3) + P(4) + P(5)$
$= {}^5C_3\left(\frac{3}{5}\right)^3\left(\frac{2}{5}\right)^2 + {}^5C_4\left(\frac{3}{5}\right)^4\left(\frac{2}{5}\right)^1$
$+ {}^5C_5\left(\frac{3}{5}\right)^5\left(\frac{2}{5}\right)^0$
$= 0.6826$

9) (i) $n = 6$
$r = 5, 6$
$p = 0.75$
$q = 0.25$

P(claim accepted) $= P(5) + P(6)$
$= {}^6C_5(0.75)^5(0.25)^1$
$+ {}^6C_6(0.75)^6(0.25)^0$
$= 0.5339$

(ii) P(claim rejected)
$= 1 -$ P(claim accepted)
$= 1 - 0.5339$
$= 0.4661$

10) $n = 8$
$r = 6, 7, 8$ (correct)
$p = \frac{1}{3}$ $q = \frac{2}{3}$
P(atleast 75% correct) $= P(6) + P(7) + P(8)$
$= {}^8C_6\left(\frac{1}{3}\right)^6\left(\frac{2}{3}\right)^2 + {}^8C_7\left(\frac{1}{3}\right)^7\left(\frac{2}{3}\right)^1 + {}^8C_8\left(\frac{1}{3}\right)^8$
$= 0.0197$

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(4)

(ii) $P(5 \text{ even}) = 2\,P(4 \text{ even})$

$^{10}C_5 p^5 q^5 = 2 \times {}^{10}C_4 p^4 q^6$

$^{10}C_5\, p = 2 \times {}^{10}C_4 \times q$

$^{10}C_5\, p = 2\, {}^{10}C_4 (1-p)$

$252p = 420(1-p)$

$672p = 420$

$\therefore p = 0.625$

$\therefore q = 1-p = 0.375$

$N = 10000$

$n = 10$; $r = 0$ (even)

$p = 0.625$ (even)

$q = 0.375$

$P(0 \text{ even}) = {}^{10}C_0 (0.625)^0 (0.375)^{10}$

$= 5.499 \times 10^{-5}$

No. of sets with 0 even

$= N \times P = 10000 \times 5.499 \times 10^{-5}$

$= 0.550$

$\simeq 1$

12) (i) $n = 3$, $p = \frac{1}{11}$, $q = \frac{10}{11}$; $n = 7$, $p = \frac{1}{21}$, $q = \frac{20}{21}$

$P(2 \text{ old } \& \text{ no new}) = P(2) \times P(0)$

$= {}^3C_2 \left(\frac{1}{11}\right)^2 \left(\frac{10}{11}\right)^1 * {}^7C_0 \left(\frac{1}{21}\right)^0 \left(\frac{20}{21}\right)^7$

$= 0.016$

(ii) $P(2 \text{ old and } 0 \text{ new}) +$

$P(2 \text{ new } \& \text{ } 0 \text{ old})$

$= {}^3C_2 \left(\frac{1}{11}\right)^2 \left(\frac{10}{11}\right)^1 \times {}^7C_0 \left(\frac{1}{21}\right)^0 \left(\frac{20}{21}\right)^7$

$+ {}^3C_0 \left(\frac{1}{11}\right)^0 \left(\frac{10}{11}\right)^3 \times {}^7C_2 \left(\frac{1}{21}\right)^2 \left(\frac{20}{21}\right)^5$

$= 0.044$

13) (i) $n = 7$

$r = 2, 3, 4, 5, 6, 7$ (hit)

$p = \frac{1}{4}$ (hit)

$q = \frac{3}{4}$

$P(\text{atleast twice})$

$= P(2) + P(3) + \cdots + P(7)$

$= 1 - P(0) - P(1)$

$= 1 - {}^7C_0 \left(\frac{1}{4}\right)^0 \left(\frac{3}{4}\right)^7 - {}^7C_1 \left(\frac{1}{4}\right)^1 \left(\frac{3}{4}\right)^6$

$= 0.5551$

(ii) $n = ?$

$r = 1, 2, 3, 4, 5, \ldots n$

$p = \frac{1}{4}$

$q = \frac{3}{4}$

$P(\text{hit atleast once}) > 2/3$

$P(1) + \cdots P(n) > 2/3$

$1 - P(0) > 2/3$

$1 - {}^nC_0 \left(\frac{1}{4}\right)^0 \left(\frac{3}{4}\right)^n > 2/3$

$\frac{1}{3} > \left(\frac{3}{4}\right)^n$

$\therefore n = 4$

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(5)

14) $n = ?$

$r = 2, 3, \ldots$ (hits)

$p = \frac{1}{2}$ (hit)

$q = \frac{1}{2}$

$P(\text{destroy target}) > 0.99$

$P(2) + P(3) + \cdots P(n) > 0.99$

$1 - P(0) - P(1) > 0.99$

$1 - {}^nC_0 \left(\frac{1}{2}\right)^0 \left(\frac{1}{2}\right)^n - {}^nC_1 \left(\frac{1}{2}\right)^1 \left(\frac{1}{2}\right)^{n-1} > 0.99$

$1 - \left(\frac{1}{2}\right)^n - n\left(\frac{1}{2}\right)^n > 0.99$

$0.01 > \left(\frac{1}{2}\right)^n (1+n)$

$\therefore n = \underline{\underline{11}}$

15) $n = 5$

$P(1) = 0.4096$

$P(2) = 0.2048$

${}^5C_1\, p^1 q^4 = 0.4096$

$5\, p(1-p)^4 = 0.4096$

$\therefore p = \underline{0.2}$

$\therefore q = 1 - p = \underline{0.8}$

16) $9\, P(4) = P(2)$

$9\, {}^6C_4\, p^4 q^2 = {}^6C_2\, p^2 q^4$

$9\, p^2 = q^2$

$9p^2 = (1-p)^2$

$\therefore p = 0.25$

(6)

TYPE II

1) $np = 3$

$npq = 1.2$

$\therefore \frac{npq}{np} = \frac{1.2}{3}$

$\therefore q = 0.4$

$\therefore p = 1 - q = 0.6$

$\therefore n(0.6) = 3$

$n = 5$

$P(X<4) = P(0)+P(1)+P(2)+P(3)$

$= {}^5C_0 (0.6)^0 (0.4)^5 +$

${}^5C_1 (0.6)^1 (0.4)^4 +$

${}^5C_2 (0.6)^2 (0.4)^3 +$

${}^5C_3 (0.6)^3 (0.4)^2$

$= 0.663$

2) $np = 6$

$npq = 16$

$\therefore \frac{npq}{np} = \frac{16}{6}$

$\therefore q = \frac{16}{6} > 1$

Not possible

$\therefore$ False.

3) $np = 5$ & $n^2p^2 + npq = 27$

$(5)^2 + npq = 27$

$npq = 2$

$\therefore \sigma = \sqrt{npq} = \sqrt{2}$

$= 1.414$

4)

x	f	fx
0	6	0
1	20	20
2	28	56
3	12	36
4	8	32
5	6	30
6	0	0
	$N = 80$	174

Mean $\bar{x} = \frac{\Sigma fx}{\Sigma f} = \frac{174}{80} = 2.175$

$\therefore np = 2.175$

$6p = 2.175$

$\therefore p = 0.3625$

$\therefore q = 1 - p = 0.6375$

x	$f = N \times {}^6C_x (0.3625)(0.6375)^{6-x}$
0	$5.37 \simeq 5$
1	$18.32 \simeq 18$
2	$26.04 \simeq 26$
3	$19.75 \simeq 20$
4	$8.42 \simeq 8$
5	$1.92 \simeq 2$
6	$0.18 \simeq 0$

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5)

x	$f = 96 \times {}^5C_x \left(\frac{1}{2}\right)^x \left(\frac{1}{2}\right)^{5-x}$
0	3
1	15
2	30
3	30
4	15
5	3

For observed mean & SD

x	f	fx	fx^2
0	1	0	0
1	10	10	10
2	24	48	96
3	35	105	315
4	18	72	288
5	8	40	200
	96	275	909

Mean (obs) $\bar{x} = \frac{\Sigma fx}{\Sigma f} = 2.865$

Mean (theoretical) $\bar{x} = np = 5\left(\frac{1}{2}\right) = 2.5$

$\sigma_{(obs)} = \sqrt{\frac{\Sigma fx^2}{\Sigma f} - \bar{x}^2}$

$= \sqrt{\frac{909}{96} - (2.865)^2} = 1.227$

$\sigma_{(theo)} = \sqrt{npq} = \sqrt{5 \times \frac{1}{2} \times \frac{1}{2}} = 1.118$

$\because$ Mean & SD of obs & theoretical are similar $\therefore$ its Binomial

6) Mean $= np = 4$

Var $= npq = \frac{4}{3}$

$\therefore \frac{npq}{np} = \frac{1}{3} \quad \therefore q = \frac{1}{3}$

$\therefore p = 1 - q = \frac{2}{3}$

$\therefore n\left(\frac{2}{3}\right) = 4$

$\therefore n = 6$

$P(x \geq 1) = P(1) + \ldots + P(6)$

$= 1 - P(0)$

$= 1 - {}^6C_0 \left(\frac{2}{3}\right)^0 \left(\frac{1}{3}\right)^6$

$= 0.9986$

7) (i) Fair coin (unbiased)

$N = 128 \quad n = 7$

$p = \frac{1}{2} \quad q = \frac{1}{2}$

x	$f = N \times {}^7C_x \left(\frac{1}{2}\right)^x \left(\frac{1}{2}\right)^{7-x}$
0	1
1	7
2	21
3	35
4	35
5	21
6	7
7	1

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(ii)

x	f_7	fx
0	6	0
1	6	6
2	19	38
3	35	105
4	30	120
5	23	115
6	7	42
7	1	7
	$N = 128$	433

Mean $\bar{x} = \frac{\Sigma fx}{\Sigma f} = \frac{433}{128} = 3.383$

$\therefore np = 3.383$

$\therefore 7p = 3.383$

$\therefore p = \underline{0.483}$

$\therefore q = 1 - p = \underline{0.517}$

$f = N \times {}^7C_x (0.483)^x (0.517)^{7-x}$

x	f
0	$1.26 \simeq 1$
1	$8.26 \simeq 8$
2	$23.16 \simeq 23$
3	$36.06 \simeq 36$
4	$33.69 \simeq 34$
5	$18.89 \simeq 19$
6	$5.88 \simeq 6$
7	$0.78 \simeq 1$

8) n = even $= 2m$

Mode $= (n+1)p$

$= (2m+1)\left(\frac{1}{2}\right)$

$= m + \frac{1}{2}$ not integer

$\therefore$ Mode $= m$

$= \frac{n}{2}$

n = odd $= (2m-1)$

Mode $= (n+1)p$

$= (2m-1+1)\frac{1}{2}$

$= m$ integer

$\therefore$ Mode $= m$ & $m-1$

$= \frac{n+1}{2}$ & $\frac{n+1}{2} - 1$

$= \frac{n+1}{2}$ & $\frac{n-1}{2}$

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