ORDRE DES INGÉNIEURS DU QUÉBEC

May 2020 SESSION

*** YOU MUST HAND IN THIS QUESTIONNAIRE WITH YOUR ANSWER BOOKLET ***
Open book exam
Calculators: only authorized models
Duration: 3 hours

14-BR-A6 HYDROLOGY

Question 1 (10 points)

You are leading a team tasked with evaluating flow probabilities for an intervention on the Rouge river in l'Ascension. Your client intends on leaving specialized research equipment for 5 years on the banks of said river, and thus wishes to set it up securely. Considering the costs involved for his research, he has requested 95% reliability over the duration of the project.

Your interns have already processed the historical data for flows in said river, under your supervision:

Average flow ($\bar{Q}$)= 375 m^3/s
Standard deviation (S) = 39 m^3/s

You must:

A) Determine the return period (T) for this project; (5 points)
B) Calculate the flow associated to the desired reliability. (5 points)
(using a normal distribution – see annex 1)

Question 2 (15 points)

You've recently inherited a large parcel of land that is it's own self contained catchment and task a contractor with installing five (5) rain gauges. He has unfortunately misread the plans and installed them as shown on the figure below (gauge 5 is not set up on your catchment).

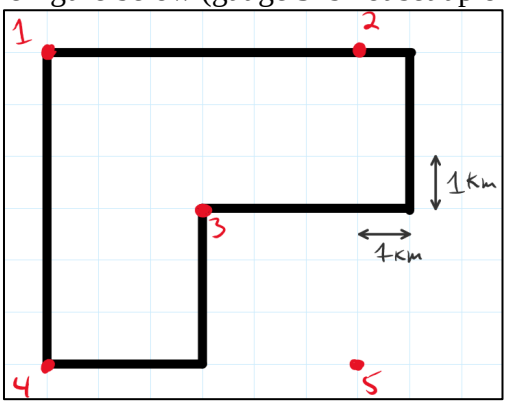


Figure 1

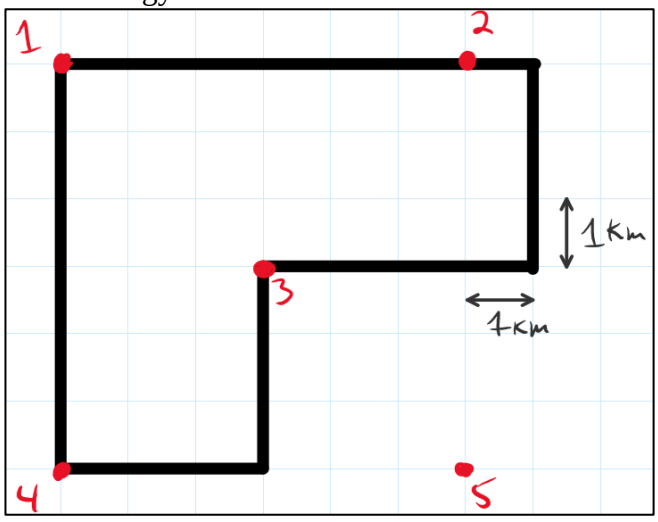
During the last rainfall event, the different gauges recorded the following cumulative data:

$P_1 = 5$ mm; $P_2 = 4$ mm; $P_3 = 4$ mm; $P_4 = 4$ mm; $P_5 = 3$ mm

Your objective is to try out three different averaging methods to establish the average rainfall on your new homestead:

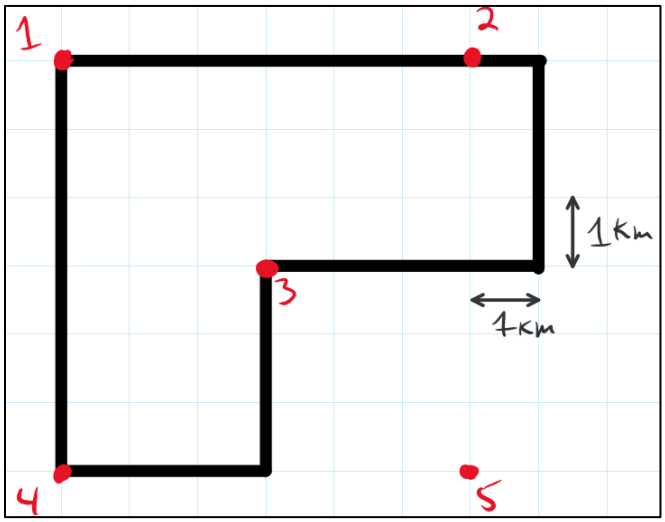
A) Arithmetic averaging; (2 points)
B) Thiessen polygon method; (5 points)
C) Isohyet method; (5 points)
D) You must also comment on each method as to their practical usefulness to this situation.
(3 points)

For methods B) and C), you must annotate and use the figures below to demonstrate your methodology. Your mathematical demonstrations can either be here or in your answer booklet.



B) Thiessen polygon method

Figure 2



C) Isohyet method

Figure 3

Question 3 (20 points)

As you lay in the grass one evening (11PM) with your significant other for a quiet moment of star gazing, your eye catches the flash of a cellphone screen. As you look, you find a weather app open on your cellphone indicating the current temperature and relative humidity are respectively 24^{o}C and 57%.

You contemplate the idea of staying out all night to catch the morning dew. Being the math wizard that you are, you decide to figure out at what time the dew will settle.

Your working hypothesis are that the current atmospheric variables will stay constant, except air temperature which began dropping at sundown (9PM today) when the recorded air temperature was 28^{o}C. You decide to establish a linear relation for air temperature as a function of time.

Question 4 (20 points)

The following figure presents you with a hydrograph resulting from a 5mm/h rainfall event whose total rainfall duration exceeded the time of concentration for the given catchment. The average runoff coefficient for the catchment surface is 0.4.

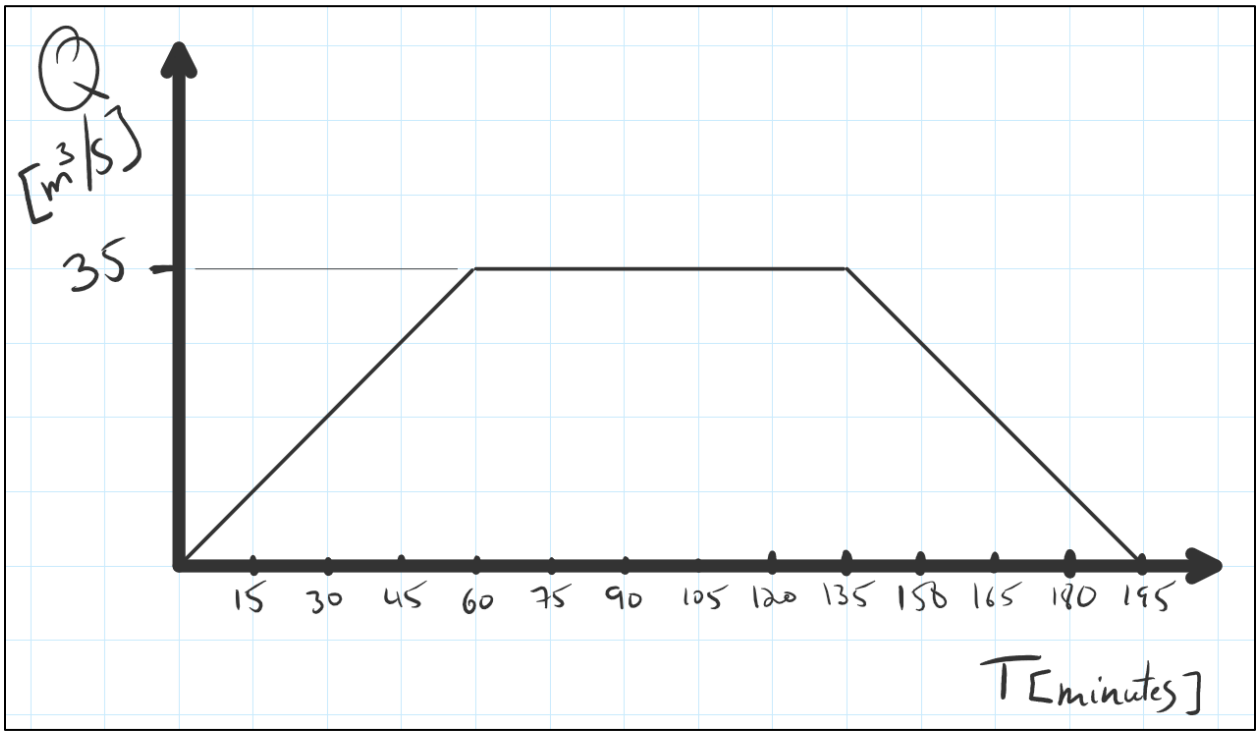


Figure 4

You must identify:

A) The time of concentration; (3 points)
   annotate the previous figure
B) The duration of the rainfall; (3 points)
   annotate the previous figure
C) Total rainfall; (3 points)
D) Net rainfall; (3 points)
E) Surface area of the catchment (you must use two different methods to calculate the area); (4 points per method)

Question 5 (15 points)

You've managed to get your hands on historical data pertaining to the snowpack present on the parcel of land mentioned in question 2. This data is for only one week in 2015 during the month of April. The snowpack had already completely melted at that point and a freak storm dumped nearly two feet of snow between April 17th and 19th. This snow had entirely melted by the 24th of April.

You're tasked with identifying the three main processes of a melting snowpack:

A) Warming; (3 points)
B) Maturation; (3 points)
C) surface runoff. (3 points)

You must annotate the graphs below to indicate from when to when each process took place (consult figures 5 to 8 but only annotate figure 5).

D) You must give a small descriptive explanation of the three processes and how they relate to the data presented on the next 4 graphs. (6 points)

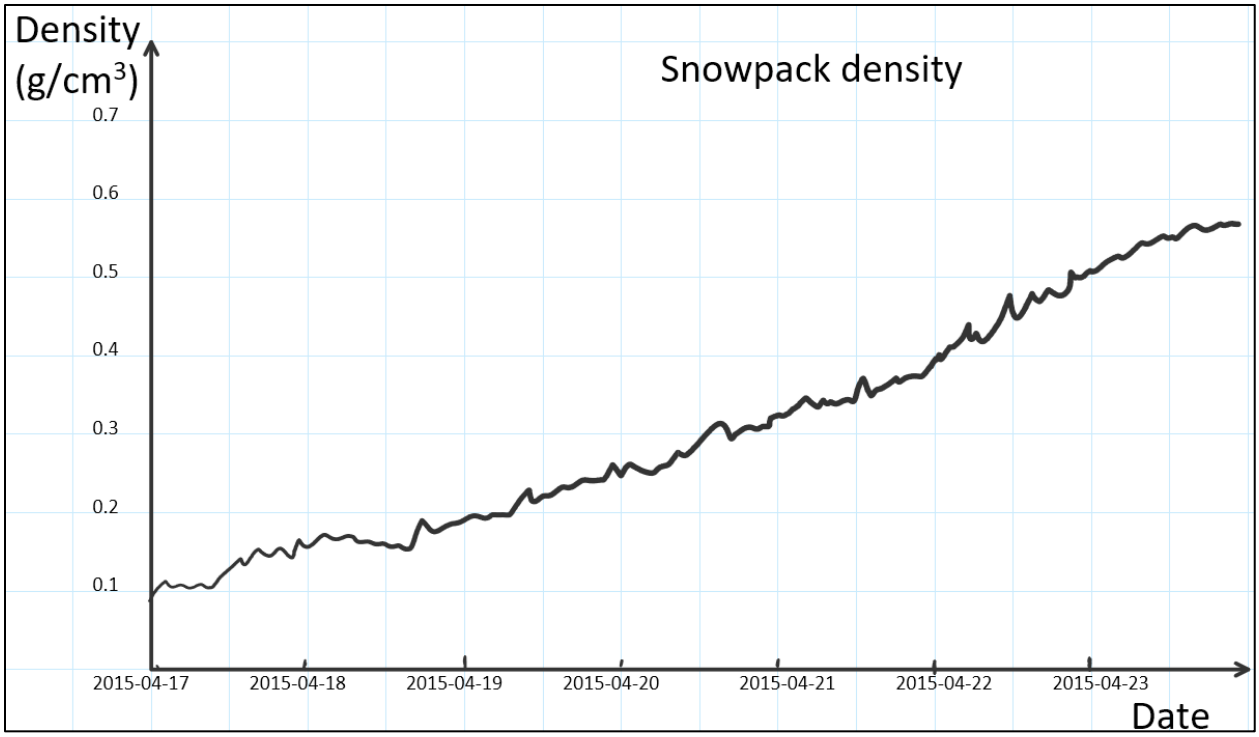


Figure 5

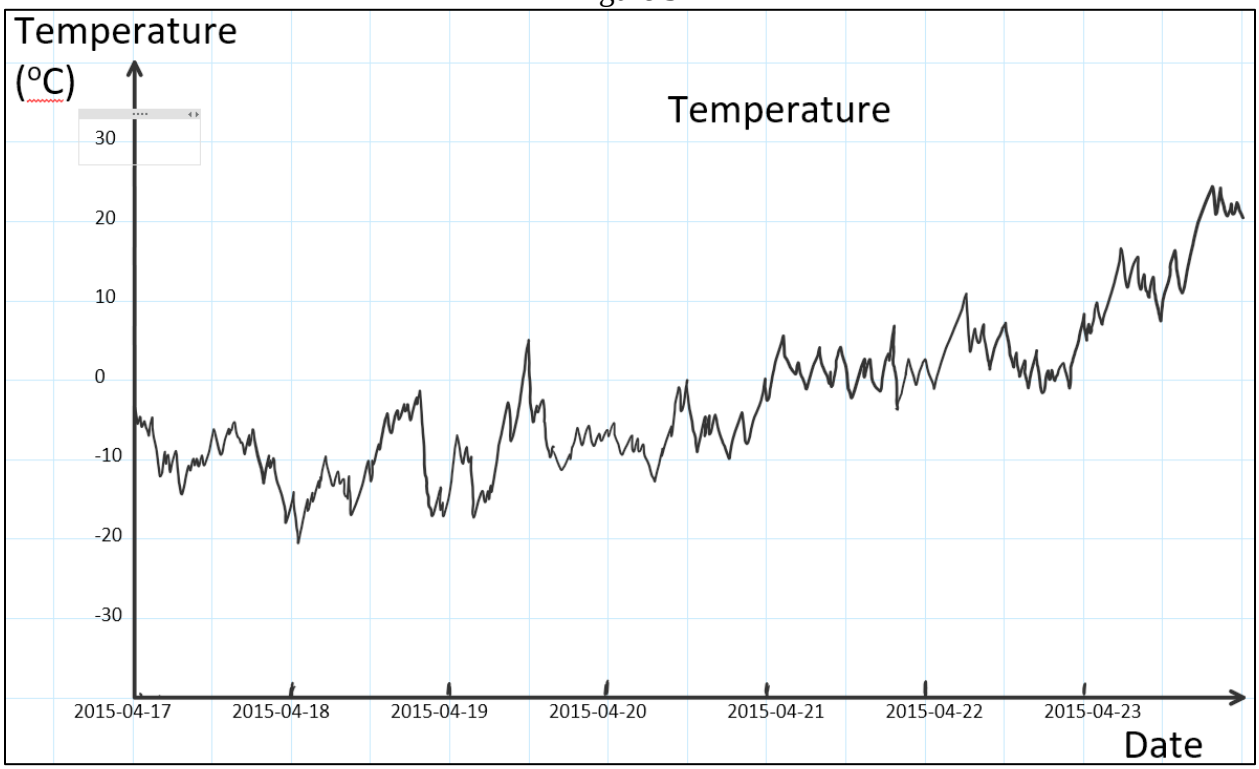


Figure 6

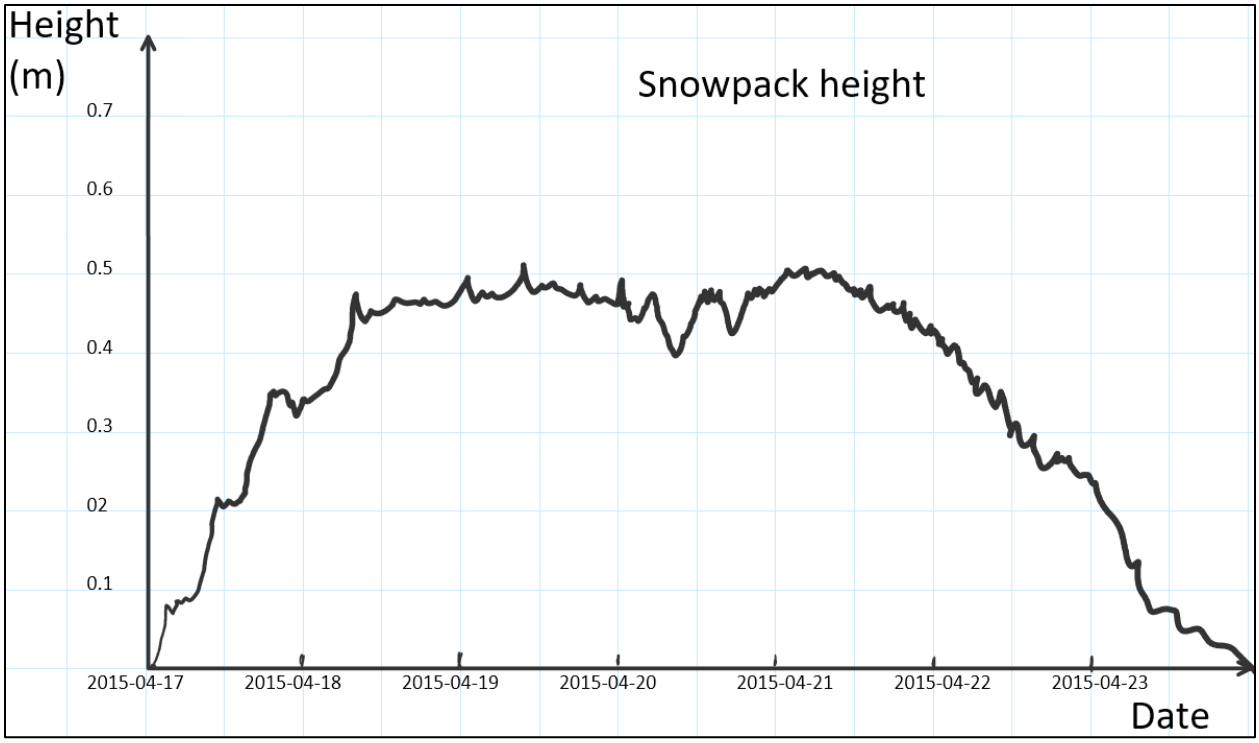


Figure 7

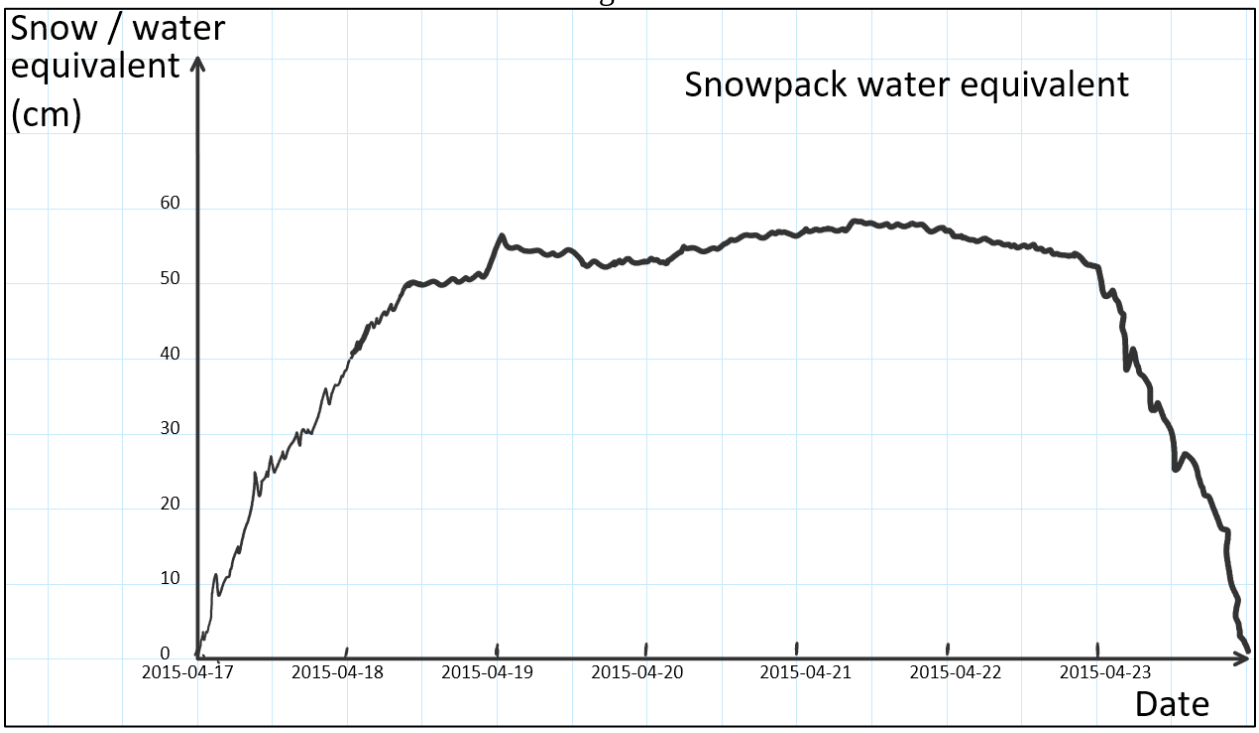


Figure 8

Question 6 (20 points)

The local fast food chain has a water detention reservoir under their parking lot. The most recent rainfall event caused it to overflow and overflow into their parking lot, effectively closing down the restaurant.

They're looking into the possibility of setting up an above ground basin to replace the underground reservoir. The current layout would allow for a maximum width of 5m as presented on figure 9. To keep inline with their popular "square burgers", the client wishes for the reservoir to be square as well.

Complete the missing data in table 1 to determine how deep the new above ground reservoir would need to be to avoid overflowing if faced with that inflow.

Outflow follows the following equation: $Q=0.05*h^{0.5}$ [m^3/s]

The reservoir can be considered initially empty.

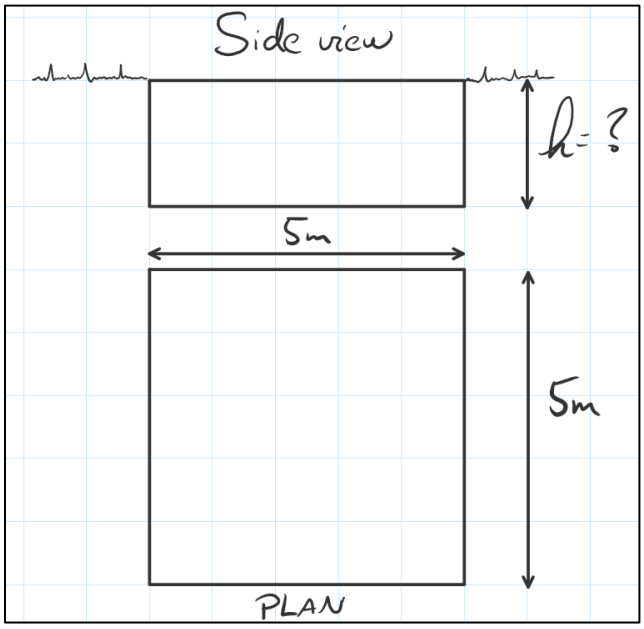


Figure 9

Table 1

Time (min)	0	15	30	45	60	75
Inflow (l/s)	0	20	40	42	22	0
Outflow (l/s)				38.7	33.6	10.85

Annex 1

Côte Z en fonction de la probabilité de non dépassement pour la loi normale

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999