Course Name: Watershed Hydrology

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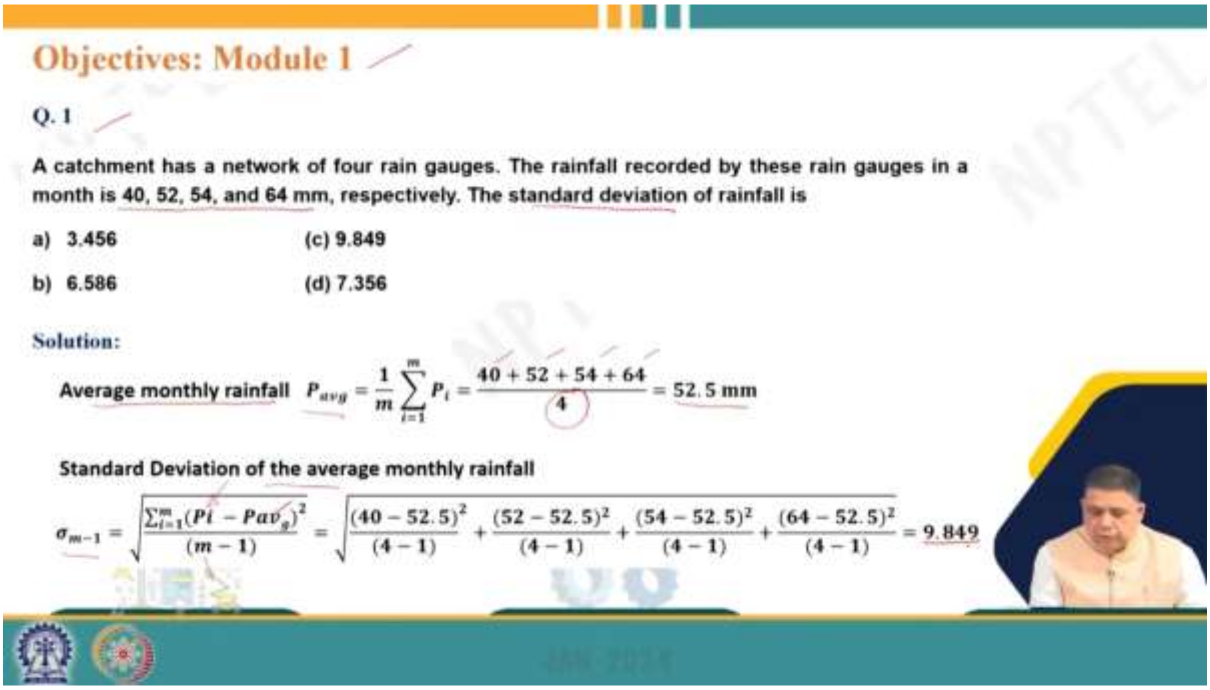
Week: 12

Lecture 59: Objectives on Watershed Hydrology

Hello friends, welcome back to this online certification course on Watershed Hydrology. I am Rajendra Singh, a Professor in the Department of Agriculture and Food Engineering at the Indian Institute of Technology Kharagpur. We are in module 12, and this is lecture number 4, where we will continue with objective-type problems on watershed hydrology.

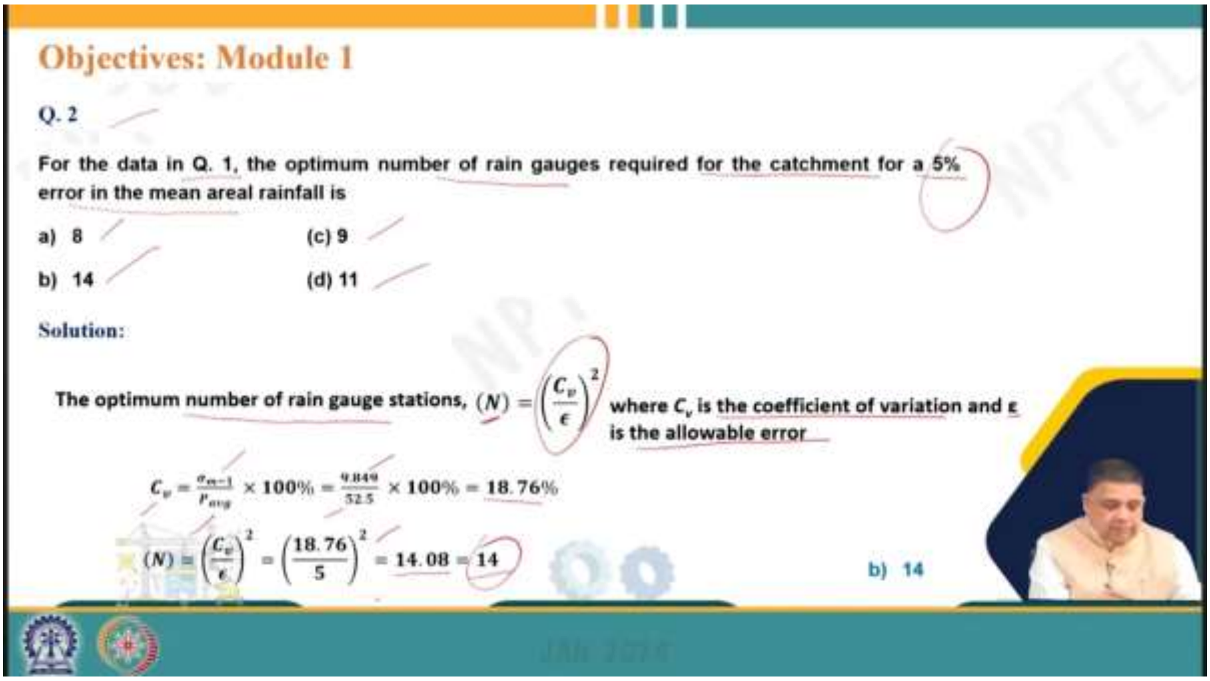


So, let's begin with the objective problem from module number 1, which is question 1.

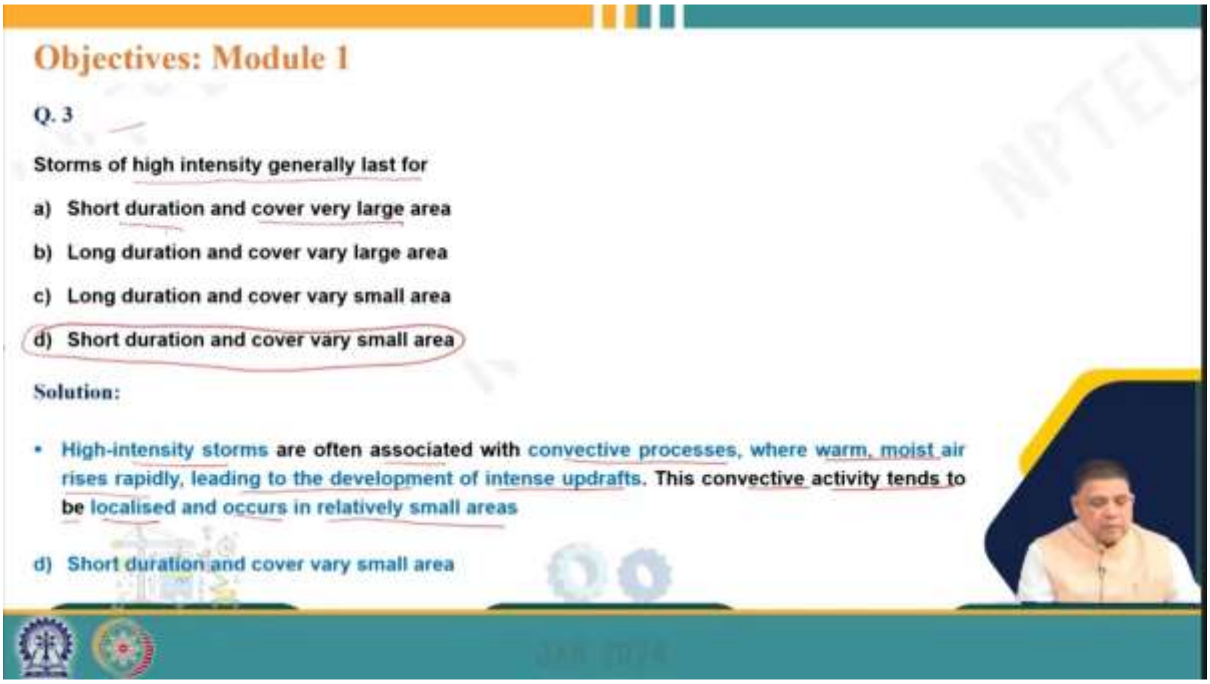
A catchment has a network of 4 rain gauges. The recorded rainfall by these rain gauges in a month is 40, 52, 54, and 64 millimetres respectively. The standard deviation of the rainfall is given as options: 3.456, 6.586, 9.849, and 7.345.

Now, let's delve into the solution. For calculating the standard deviation, we need the average monthly rainfall, denoted as P average. We can calculate this using the formula: $P_{avg} = \frac{1}{m}\sum_{i=1}^{m} Pi$, where m is the number of stations and P_i is the rainfall recorded at individual stations. Given that the recorded rainfall values are 40, 52, 54, and 64, and the number of stations (m) is 4, the average comes out to be 52.5 mm.

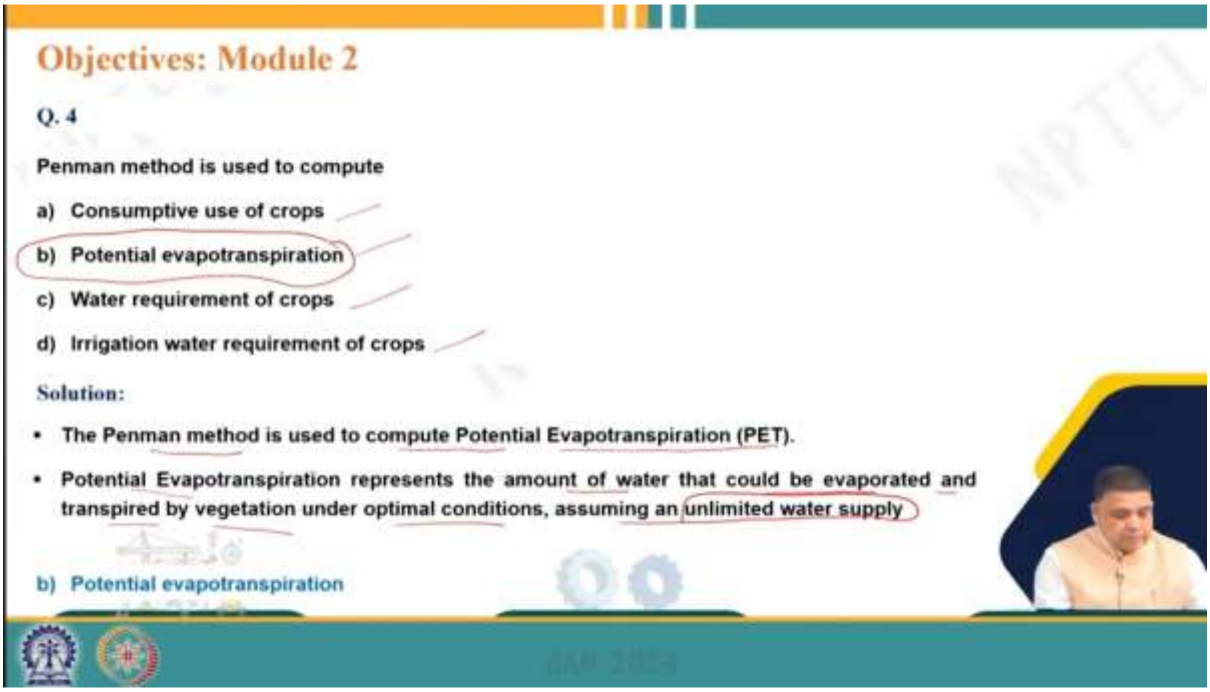
Now, we can use the standard deviation formula: $\sigma_{m-1} = \sqrt{\frac{\sum_{i=1}^{m}(Pi - Pavg)^2}{(m-1)}}$. We have the values of Pi and P average, and we know m is 4. Plugging in these values, we calculate the standard deviation to be 9.849. This means the standard deviation of the rainfall for the given data is 9.849, and option C is the correct answer.



Moving to the next question, question 2, which is a continuation of question 1. For the data in question 1, the optimum number of rain gauges required for the catchment for a 5 percent error in the mean area rainfall is given as 8, 14, 9, and 11. We know that the optimum number of rain gauge stations (n) can be found using the relationship where Cv is the coefficient of variation of the rainfall recorded data and ε is the allowable error, given as 5 percent. So, we calculate the value of Cv, which is standard deviation by mean. From the previous problem, we calculated both standard deviation (9.849) and mean (52.5 mm). Plugging in these values, we get Cv as 18.6467 percent. Now, with the values of Cv and ε, the value of n will be 18.76525218.76, which is approximately 14.08 or 14. Therefore, the optimum number of rain gauges in the catchment for a 5 percent error in the mean rainfall is 14, and option B is the correct answer. It's a straightforward application of the formulae.

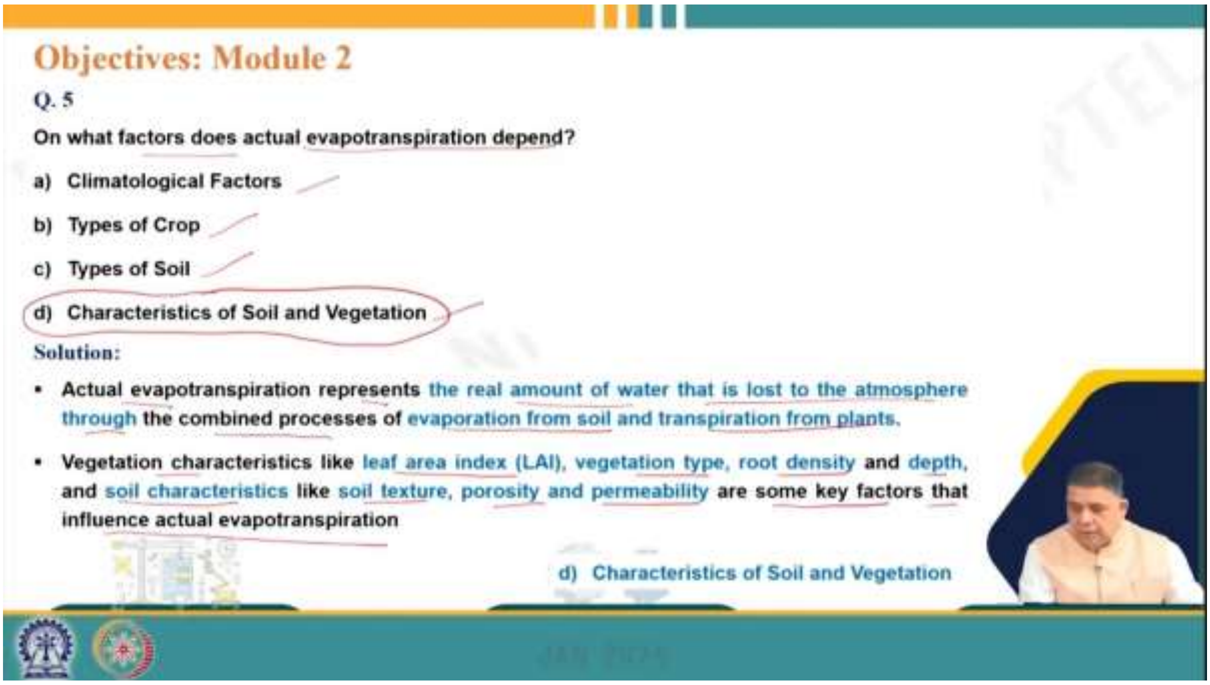


Next, question number 3 states that storms of high intensity generally last for short duration and cover a very large area, long duration cover a very large area, long duration cover a very small area, and short duration cover a very small area. We know that high-intensity storms are often associated with convective processes where warm, moist air rises rapidly, leading to the development of intense updrafts. This convective activity tends to be localized and occurs in relatively small areas. Additionally, high-intensity storms are always short-duration. Therefore, option D, short duration, and cover a small area is the correct answer.

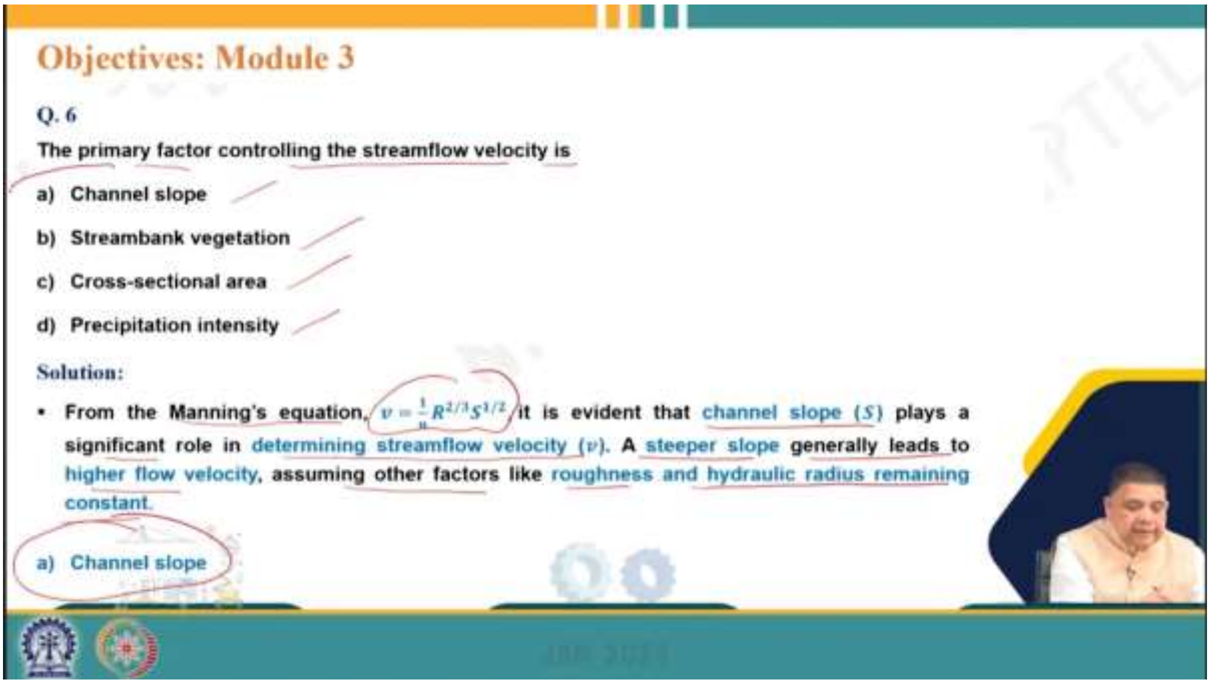


Moving to question number 4, the Penman method is used to compute consumptive use of what crops, potential evapotranspiration, water requirement of crops, or irreversible water requirements of crops. Now, we know very well that the name Penman is associated with potential evapotranspiration. So, the Penman method is used to compute potential evapotranspiration (PET), where PET represents the amount of water that could be evaporated and transpired by vegetation under optimal conditions, assuming an unlimited water supply. Therefore, the Penman method is associated with potential evapotranspiration.

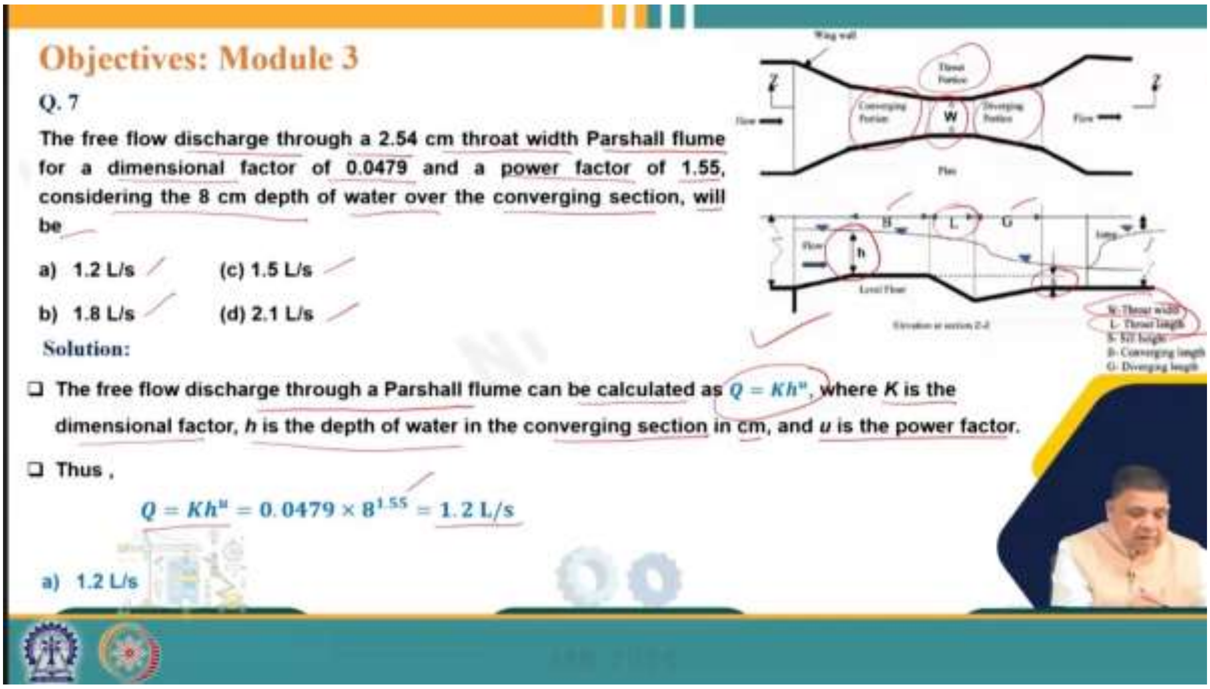
So, obviously, option B is the correct answer.



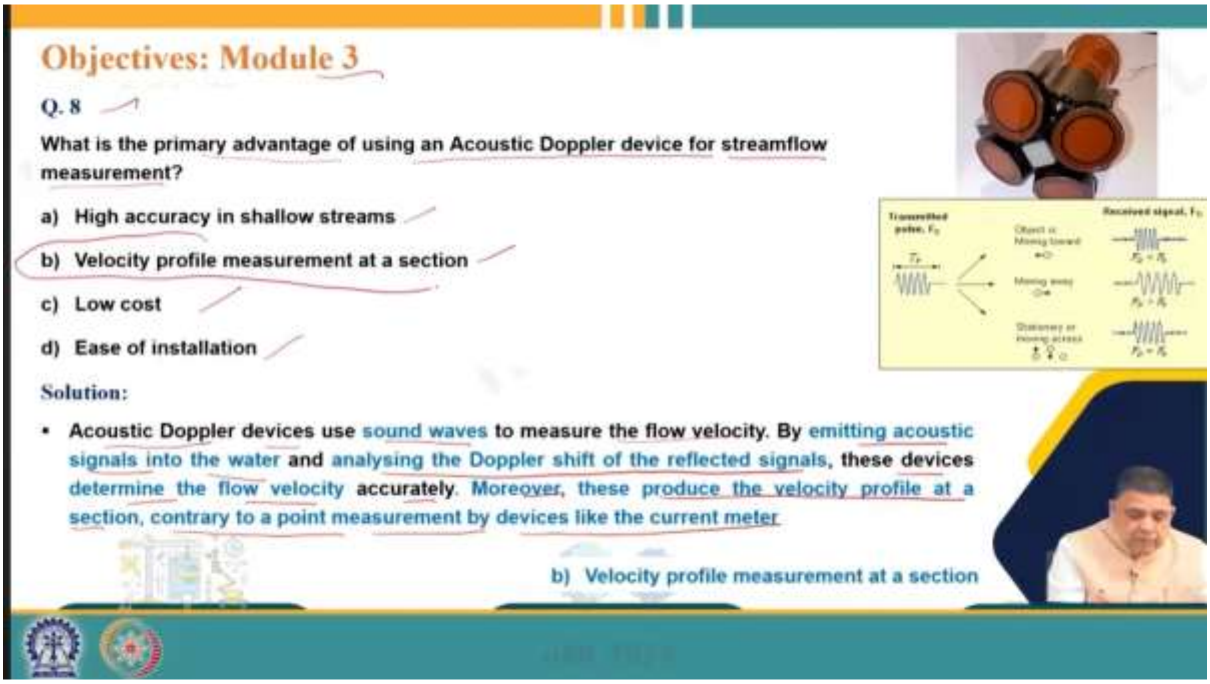
Then we move to the next question, question 5, on what factors actual evapotranspiration depends on: climatic factors, types of crops, types of soil, characteristics of soil, and vegetation. Now, we know that the actual evapotranspiration process represents the real amount of water lost to the atmosphere through the combined processes of evaporation from soil and transpiration from plants. This means both soil and plants come into the picture as far as actual evapotranspiration is concerned. Vegetation characteristics like leaf area index, vegetation type, root density and depth, and soil characteristics like soil texture, porosity, and permeability are some key factors that influence actual evapotranspiration. So, option D, which states that characteristics of both soil and vegetation impact actual evapotranspiration, is the correct answer.



Now, we move to the next question, question 6. The primary factor controlling stream flow velocity is channel slope, stream bank vegetation, cross-sectional area, or precipitation intensity. Now, we know that stream flow velocity is typically calculated using Manning's equation, given by the formula $V=\frac{1}{n}R^{2/3}S^{1/2}$. From this equation, it's evident that channel slope plays a significant role in determining stream flow velocity. Velocity is directly proportional to the square root of the slope (S). So, a steeper slope generally leads to higher flow velocity, assuming other factors like roughness and hydraulic radius remain constant. Thus, option A, channel slope, is the most appropriate answer for this question.

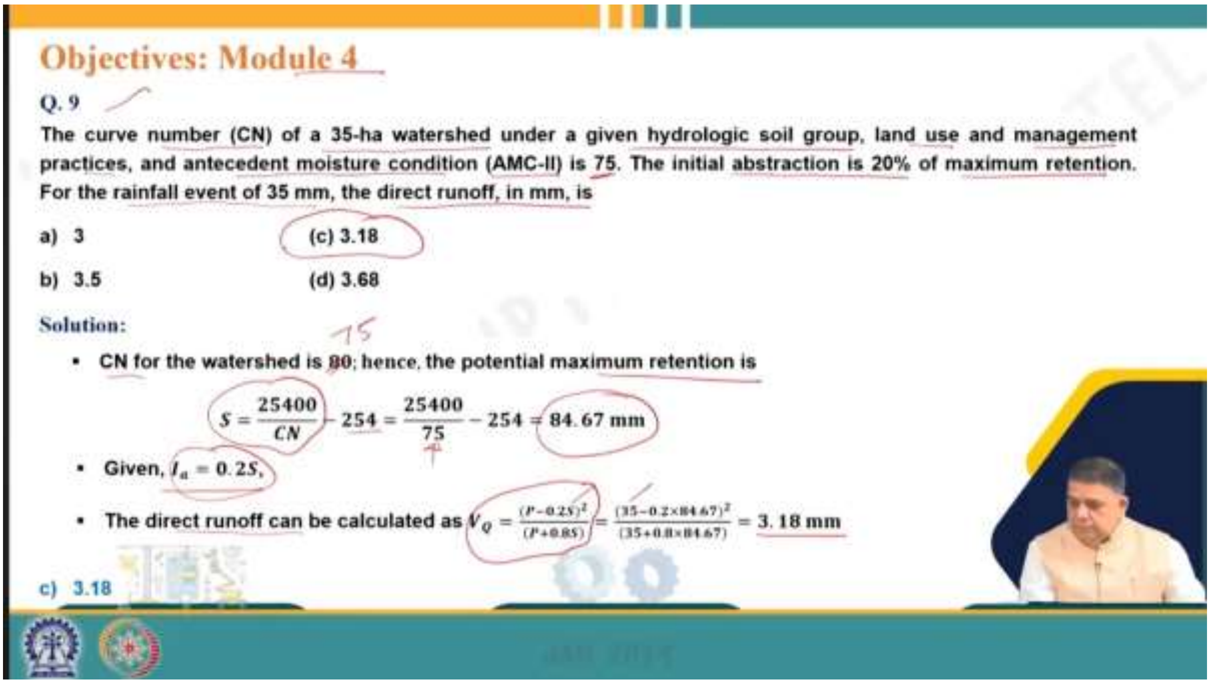


Moving on to question number 7. The free flow discharge through a 2.54-centimetre throat width partial flume, considering a dimensional factor of 0.0479 and a power factor of 1.55, with 8 centimetres depth of water over the converging section, will be. The options given are 1.2 liters per second, 1.8 liters per second, 1.5 liters per second, and 2.1 Liters per second. We discussed in module 3 how a partial flume looks like and its sections: converging section, throat section, and diverging section. The important variables include throat width (W), throat length (L), sill height (S), length of converging and diverging sections (B and C), and the head (H) in the converging section. The free flow discharge through a partial flume can be calculated using the relationship $Q=Kh^u$, where K is the dimensionless factor, H is the depth of water in the converging section centimetres, in and U is the power factor. Given the values of K, H, and U, we can plug them into the formula: $0.0479\times8^{1.55}$. The answer comes out to be 1.2 liters per second, meaning option A is the correct answer for this problem.

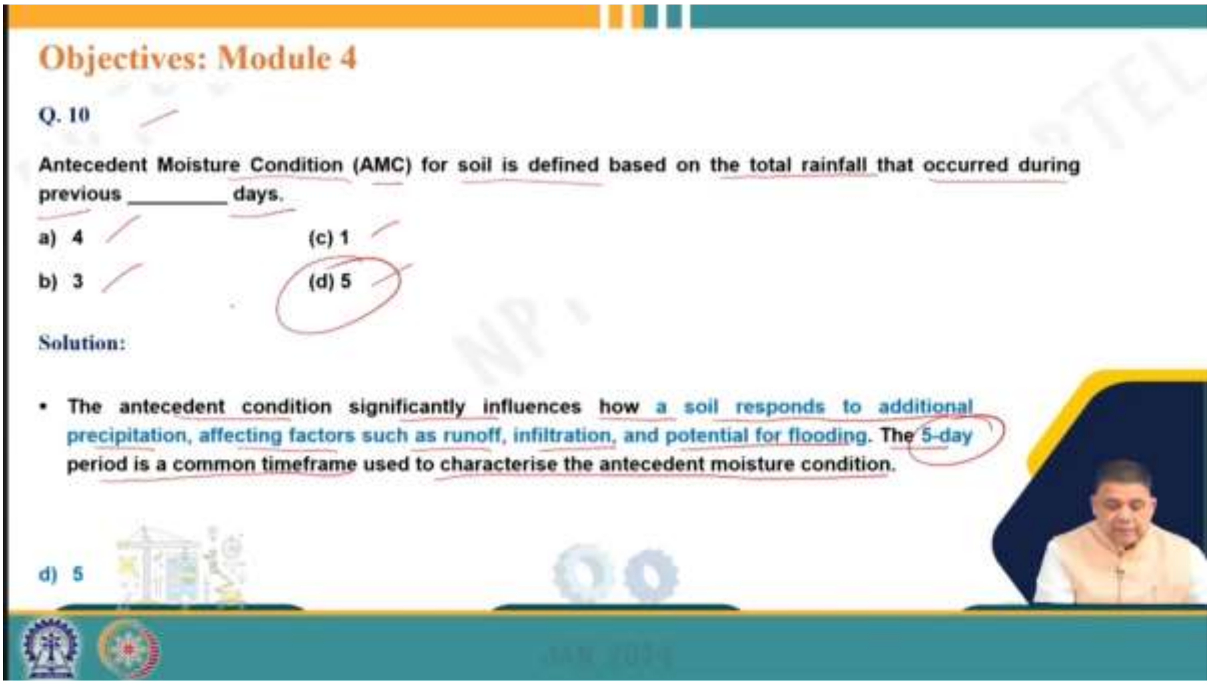


Moving to question number 8, which is also from module 3, what is the primary advantage of using an acoustic Doppler device for stream flow measurement? The options given are high accuracy in shallow stream velocity profile measurement at a section, low cost, and ease of installation. We discussed the ADCP in detail in one of the lectures. Acoustic Doppler devices use sound waves to measure flow velocity by emitting acoustic signals into the water and analysing the Doppler shift of the reflected signals. These devices determine flow velocity accurately and produce the velocity profile at a section, contrary to point measurement by devices like current meters. Therefore, the primary advantage of using an acoustic Doppler device is high accuracy in shallow stream velocity profile measurement at a section.

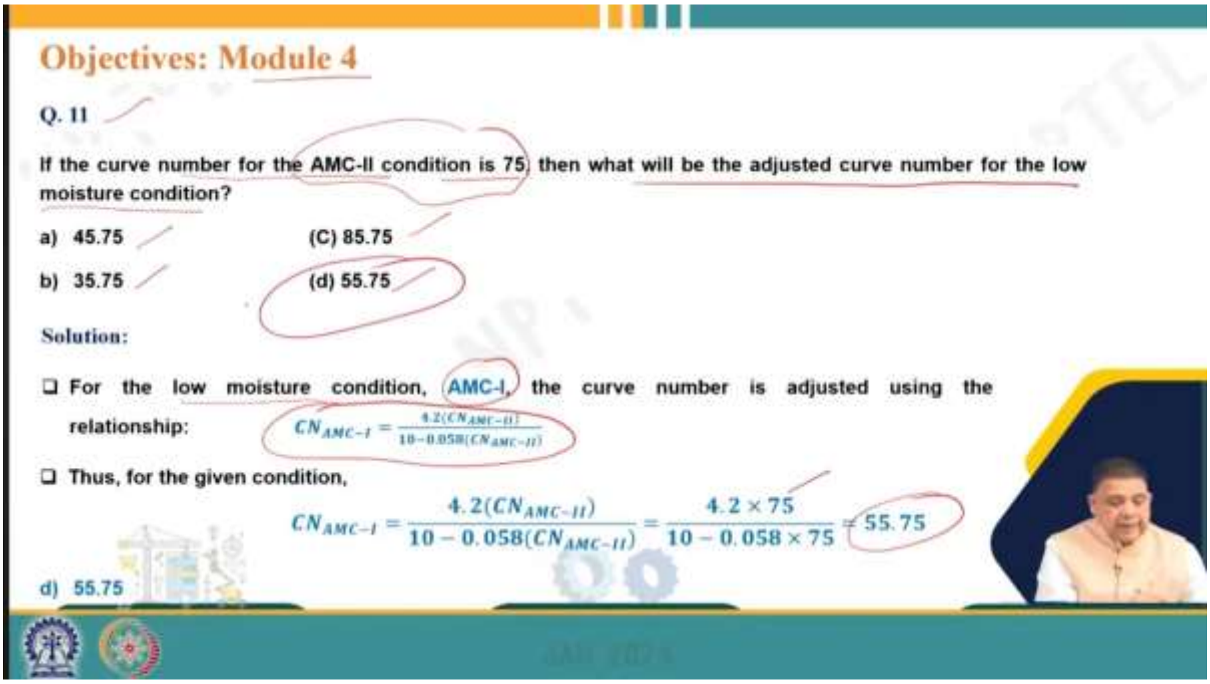
So, we know that current meters are other popular devices, but they always give a point measurement. So, the advantage of acoustic Doppler devices is that they do provide velocity profile measurement at a section and that is why option B velocity profile measurement at a section is the correct option here.



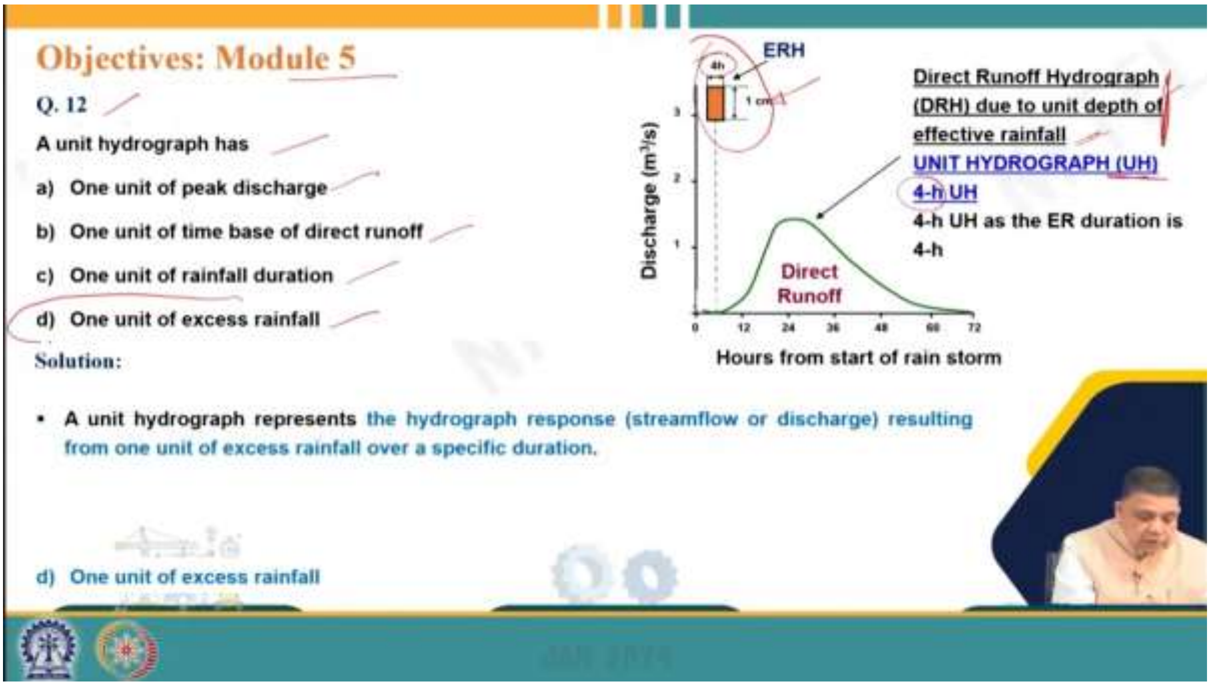
We go to question number 9 which is from module 4 the curve number CN of a 35-hectare watershed under a given hydrologic soil group land use and management practices and antecedent moisture condition (AMC II) is 75. So, the curve number value is given under AMC 2 that is standard condition the initial abstraction is 20 percent of maximum retention for the rainfall event of 35 mm the direct runoff in mm is 3 3. 5 3.1 3.68. So, the curve number for the watershed is 75 not 80 75. Hence the potential maximum retention can be obtained using this relationship S $=\frac{25400}{CN} - 254$ that is in millimeters. So, obviously, if you put the value of CN 75 here we get a value of S that is maximum potential retention in 84.67 millimetres and we have also be given initial abstraction I_a is 20 percent of maximum retention or 0. 2 S. So, the direct runoff can be calculated using the standard curve number equation SES curve number equation $V_Q = \frac{(P-0.2S)^2}{(P+0.8S)}$ and we are given the values of P and S already we have estimated this formula comes when I_a equals to 0.2 S. So, that is how we are directly using this formulation and that is putting the values of P and S in this formulation we get V_Q value of 3. 18 millimetres. So, the direct runoff for the given data using the curve number technique is 3.8 mm. So, that is option C is the correct answer.



Then we go to question number 10 the anticipate moisture condition AMC for soil is defined based on the total rainfall that occurred during previous dash days the options are 4 3 1 and 5 and the anticipate moisture condition significantly influences how a soil response to additional prediction affecting factors such as runoff infiltration and potential for flooding and the 5-day period is common time frame used to characterize the anticipate moisture condition. So, that the 5 day is the correct answer. So, option D is correct option here for this terminal that is for AMC we consider 5 days previous rainfall.



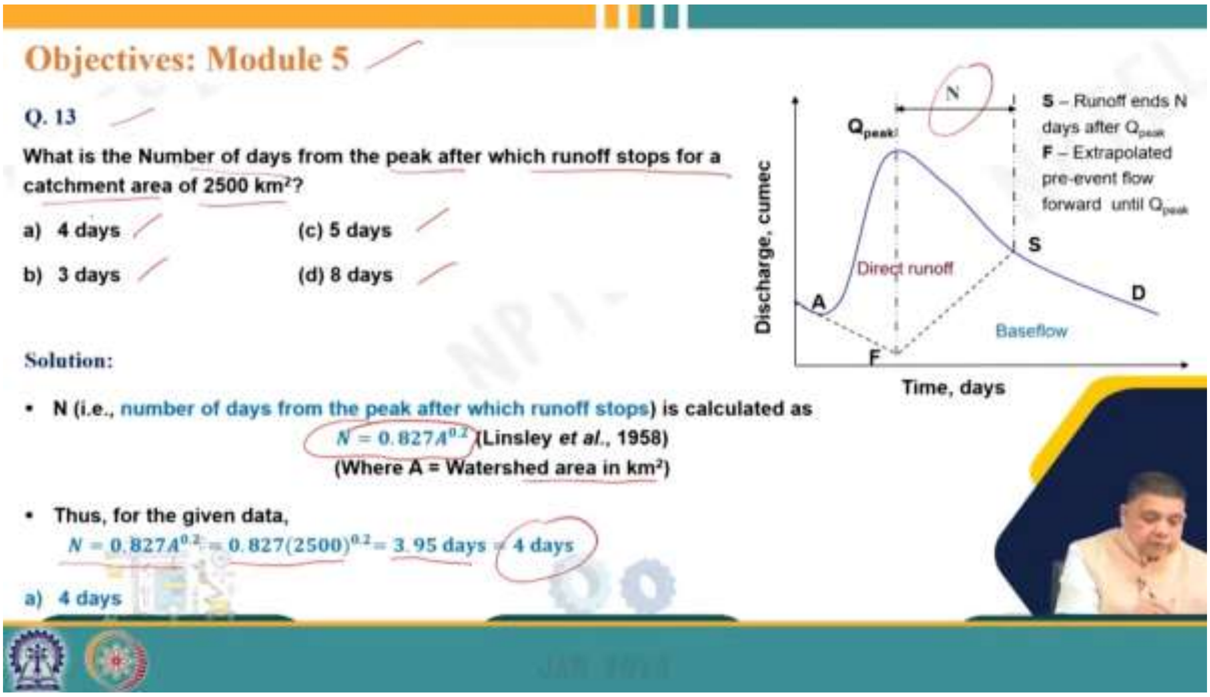
We continue with module 4 and go to question number 11 again a question of curve number if a curve number for AMC 2 condition is 75 then what will be the adjusted curve number for low moisture condition the values given are 45.75 ,35.75, 85.75 and 55.75 and we know that AMC II is the standard condition and then we have tables or equations available using that we can get the equivalent dry or moist condition that is. So, obviously, for low moisture condition we need curve number for AMC 1 and that means we must use this relationship where curve number of AMC 1 is expressed in terms of gain curve number of AMC II which is given as 75. So, that means we can straight away put the values of CN AMC II which is 75 and calculate the value. So, $CN_{AMC\text{-}I}$ is 4.2 times 75 divided by 10 minus 0.05 8 times 75 and the value which we get is 55. 75. So, the curve adjusted curve number for AM low moisture condition or AMC I is 55.75 that means option D is the correct answer.



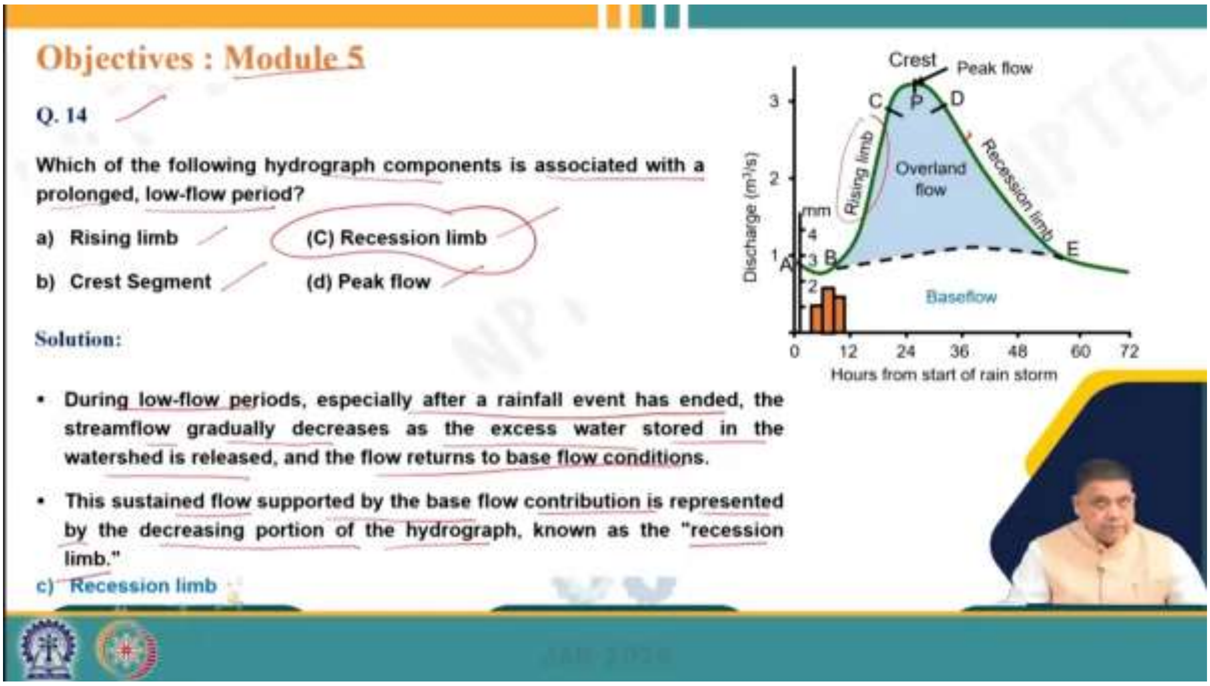
Moving to module 5, which is on hydrograph, let's look at question number 12. A unit hydrograph has one unit of peak discharge, one unit of time base of direct runoff, one unit of rainfall duration, or one unit of excess rainfall. So, it's a pretty simple problem, but a little confusing, just testing your concept. We know that a unit hydrograph represents the direct runoff hydrograph due to a unit depth of effective rainfall.

So, if you remember the definition, a direct runoff hydrograph due to a unit depth of effective rainfall. Here, in this example, a unit depth of 1 centimetre is considered, and the x-axis represents the duration of effective rainfall over which this 1 centimeter occurred. That's why whenever we refer to a unit hydrograph, we always specify the time as a suffix. So, when we say "4-hour UH," it means 1 centimeter of active rainfall occurred over 4 hours. So, that is the duration. Therefore, the correct answer for this question will be one unit of excess rainfall, which is option D.

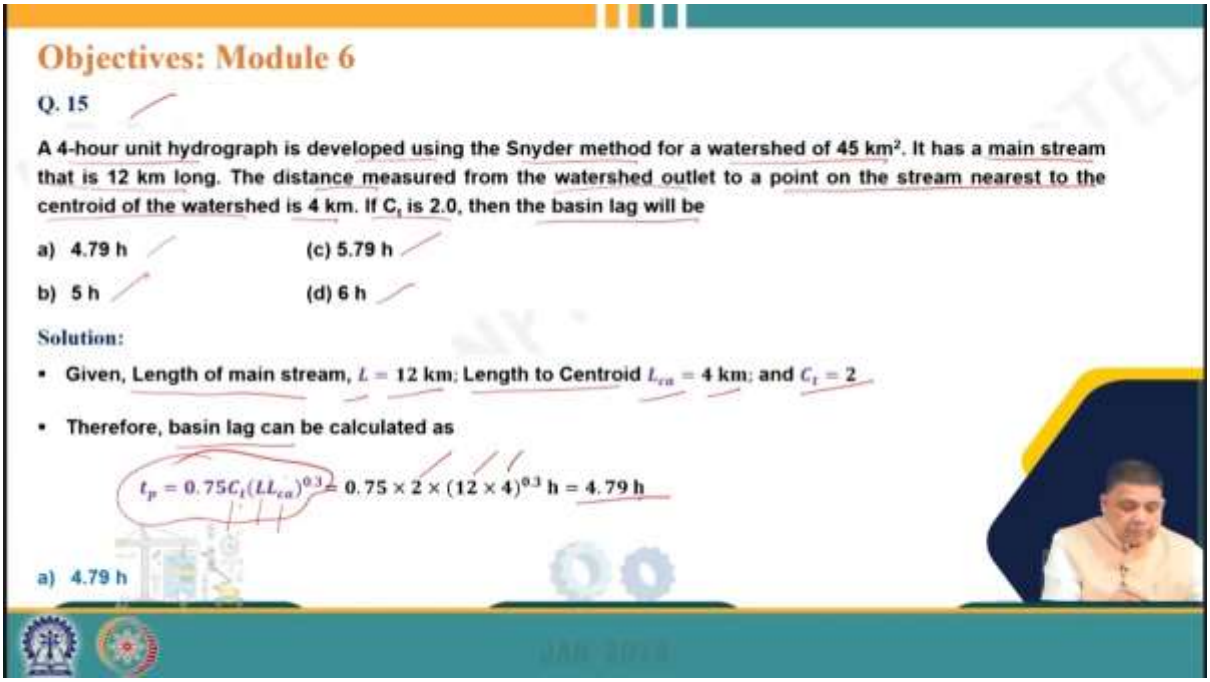
Basically, if you remember the definition of a unit hydrograph, you can easily solve this very simple problem.



Moving on to question number 13 from module 5. What is the number of days from the peak after which runoff stops for a catchment area of 2500 square kilometres? The options are 4 days, 3 days, 5 days, and 8 days. Again, it's a hydrograph problem where we need to find out nn, the number of days from the peak after which runoff stops. This nn can be calculated using the Linsley equation, given as N=0.827×$A^{0.2}$, where A is the watershed area in square kilometers. We have been given A=2500 square kilometers, so it's a direct application of this formula. By plugging in the value of A in this equation, 0.827×$2500^{0.2}$, we get an answer of 3.95 days, which is equivalent to 4 days. So, that's why option A is the correct answer. Basically, it's a direct application of a hydrograph relationship.

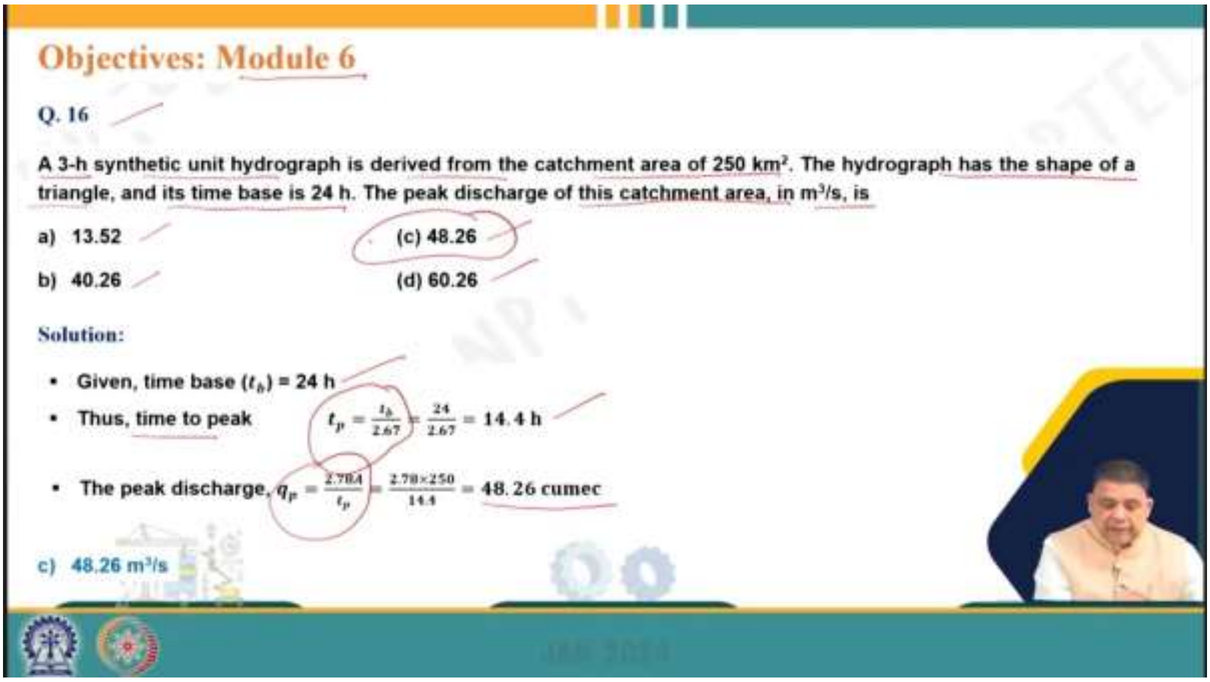


Moving on to question number 14, again, within module 5. Which of the following hydrograph components is associated with a prolonged low flow period: rising limb, crest segment, recession limb, or peak flow? These are the various segments given. Of course, we know that during low flow periods, especially after a rainfall event has ended, the stream flow gradually decreases as the excess water stored in the watershed is released, and the flow returns to base flow conditions. So, that's typically what happens, and this sustained flow, supported by the base flow contribution, is represented by the decreasing portion of the hydrograph known as the recession limb. Therefore, option C, recession limb, is the correct answer for this question.

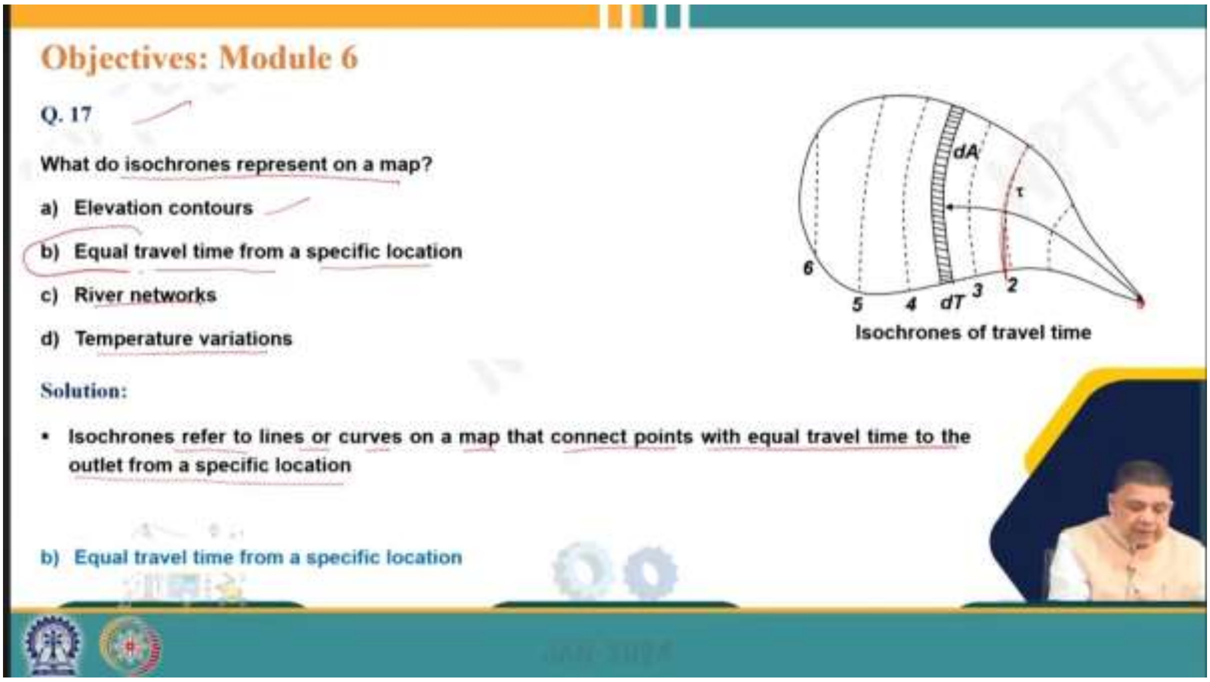


Moving on to question number 15, from module 6. A 4-hour unit hydrograph is developed using the Snyder method for a watershed of 45 square kilometers. It has a main stream that is 12 kilometers long, and the distance measured from the watershed outlet to a point on the stream nearest to the centroid of the watershed is 4 kilometers. If $C_t$is 2, then the basin lag will be. The options are 4.7 hours, 7.9 hours, 5 hours, 5.79 hours, or 6 hours. Basically, it is a direct application of the Snyder method equation. We have been given the length of the main stream (L) as 12 kilometers, the length to the centroid (L_{ca}) as 4 kilometers, and C_t as 2. According to the Snyder method, the basin lag (h) is given by the relationship $t_p=0.75C_t(L*L_{ca})^{0.3}$. So, we have been given the values of C_t, L, and L_{ca}.

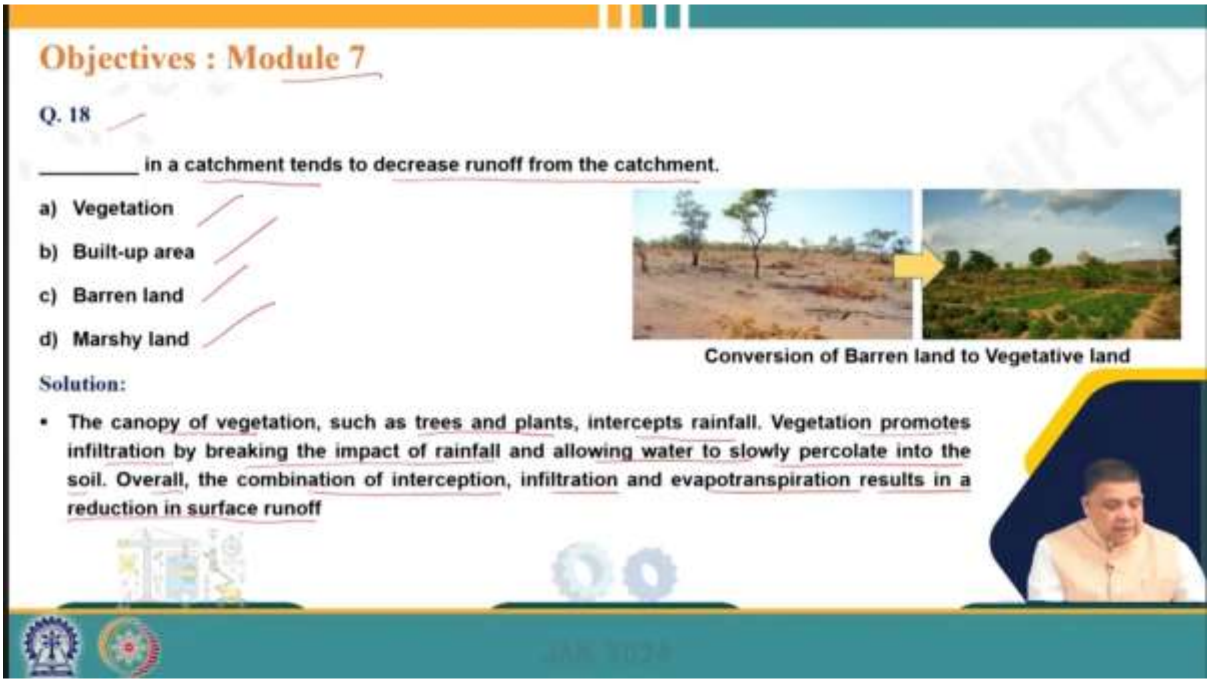
So, putting the values, we get $0.75x2x(12x4)^{0.3}$. Therefore, t_p is in hours, and we get the answer as 4.79 hours. So, option A is the correct answer for this particular problem.



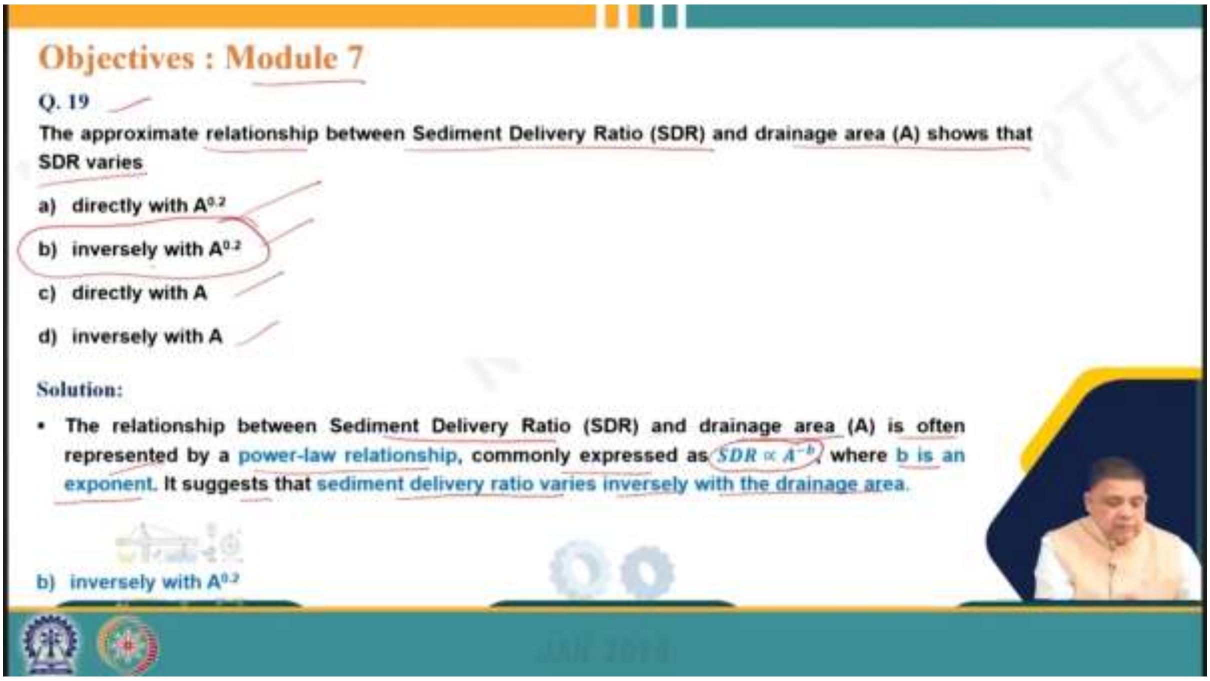
Moving on to the next one, question 16, again from module 6. A 3-hour synthetic unit hydrograph is derived from a catchment area of 250 square kilometers. The hydrograph has the shape of a triangle, and its time basis is 24 hours. The peak discharge of this catchment area in cubic meters per second is 13.5, 40.26, 48.26, and 60.26. The four different answers are given here, and the time basis given is 24 hours. We know that this is a triangular unit hydrograph. The SCS triangular unit hydrograph procedure has been used to derive this unit hydrograph because of the given statement. So, the time to peak (t_p) as per the SCS triangular hydrograph method is $t_p=\frac{tb}{2.67}$, and t_b is the time basis given as 24 hours. By putting this value here, we get t_p=14.4 hours. So, $t_p$value is calculated, and the peak discharge (q_p) can be calculated using this relationship:$\frac{2.78\times A}{tp}$. Since t_p, A, and the units are given, we can directly substitute these values and find q_p as 48.26 cumecs. So, that simply means option C is the correct answer for this particular question.



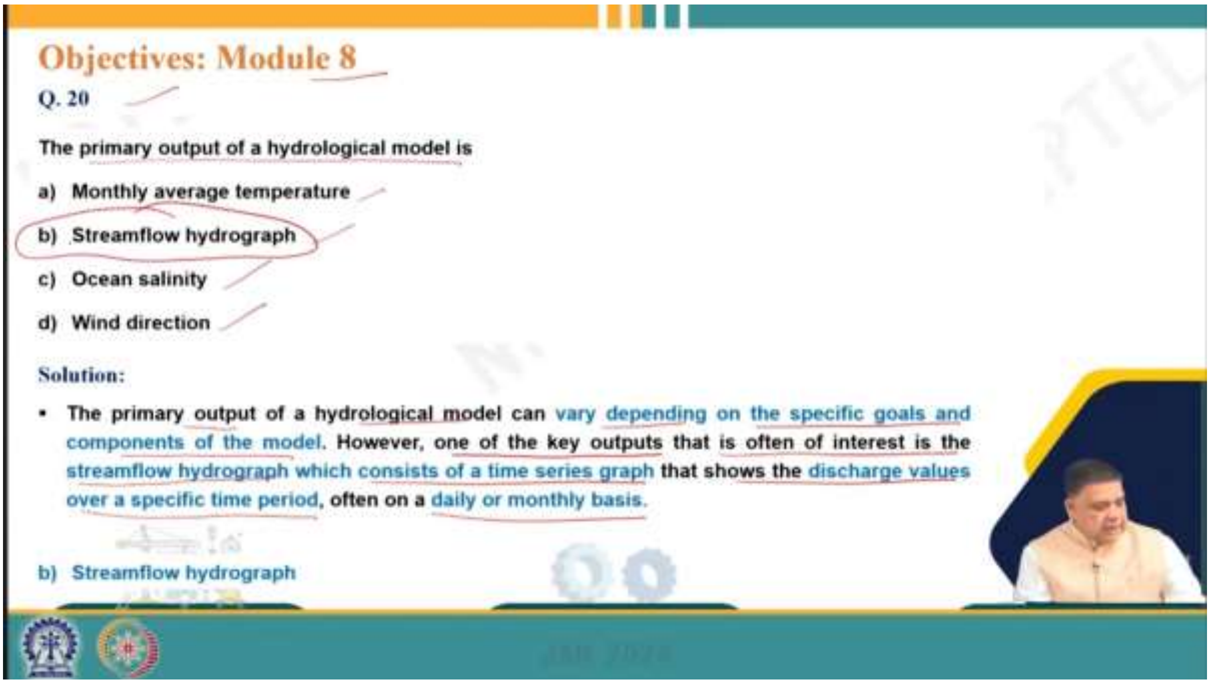
We go to question number 17. What do isochrones represent on a map? Elevation contours equal travel time from a specific location, river networks, or temperature variation? If you know isochrones, the definition of isochrones, we know that isochrones refer to lines or curves on a map that connect points with equal travel time to the outlet from a specific location. As you can see here from this picture, that simply means that from this point to the outlet, the entire area will be contributing for 2 hours. In 2 hours', time, the travel time is 2 hours for the entire area. So, that is how isochrones are drawn for different travel time periods. So, the correct answer is equal travel time from a specific location, which means option B.



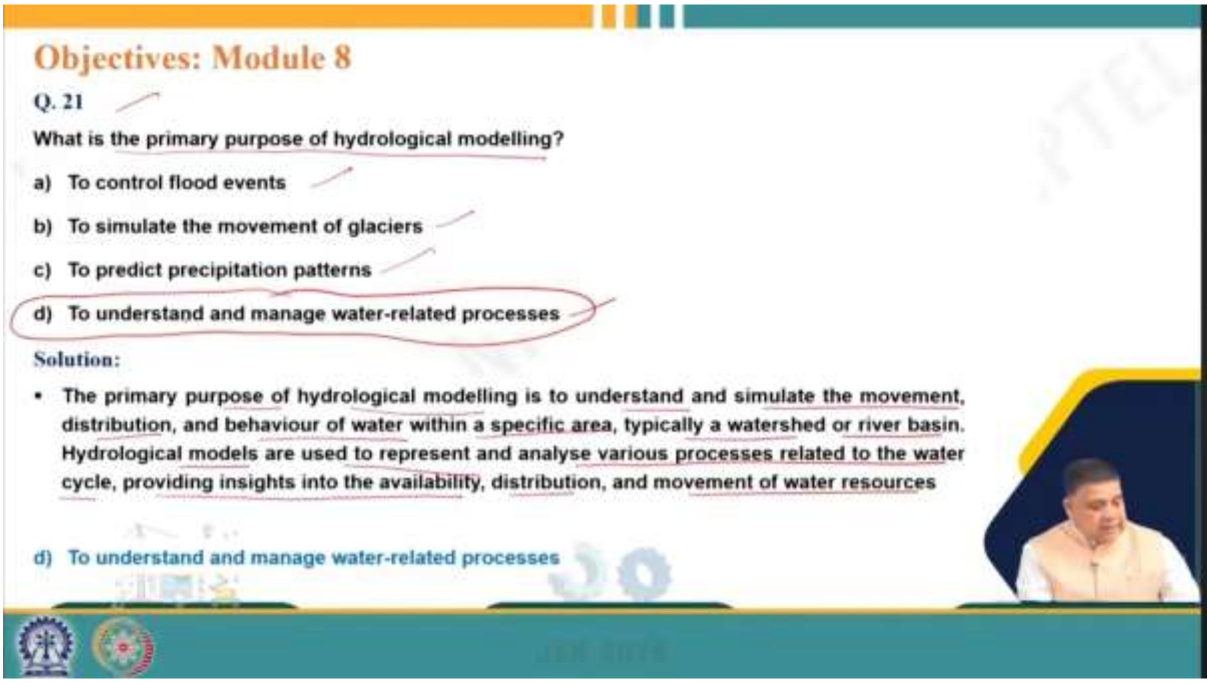
Then we go to question number 18 from module 7. In a catchment, what tends to decrease runoff from the catchment? Vegetation, built-up area, barren land, or marshy land? Of course, we know that the canopy of vegetation such as trees and plants intercept rainfall. Vegetation promotes infiltration by breaking the impact of rainfall, allowing water to slowly percolate into the soil. Overall, the combination of interception, infiltration, and evapotranspiration results in the reduction in surface runoff. So, it is the vegetation that tends to decrease runoff from a given catchment. Therefore, option A, vegetation, is the correct answer.



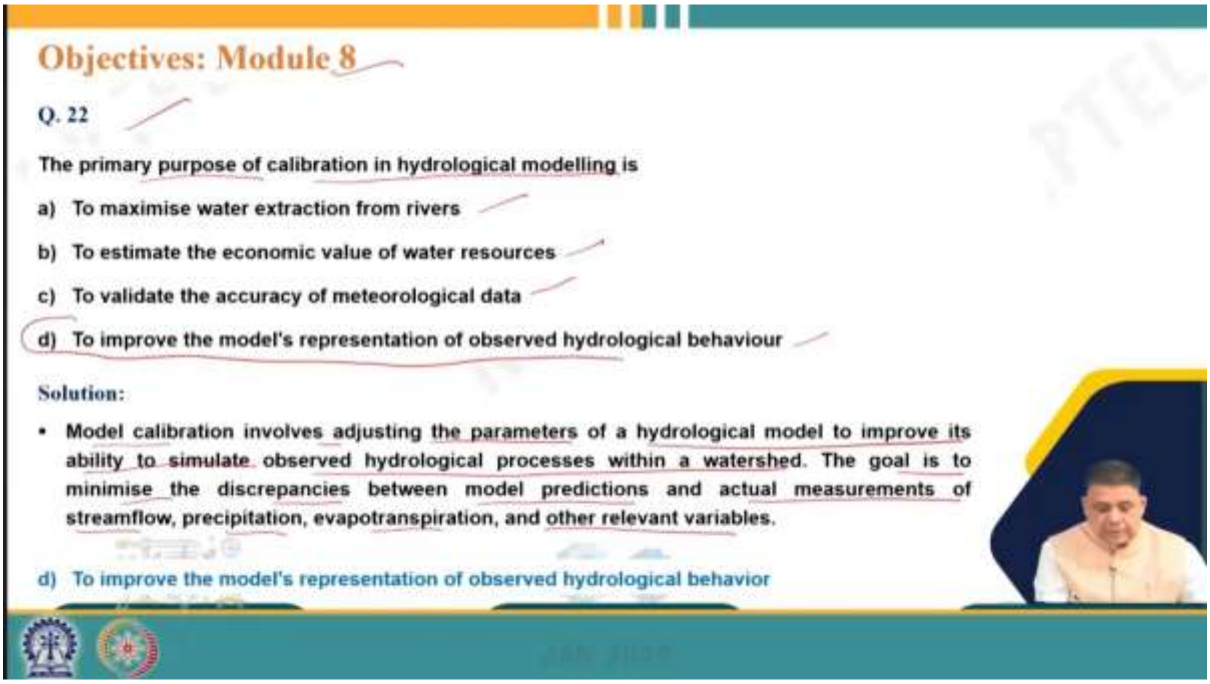
Moving to question number 19, still within module 7. The approximate relationship between sediment delivery ratio and drainage area shows that SDR varies directly with $A^{0.2}$, inversely with $A^{0.2}$, directly with A, or inversely with A? The relationship between SDR and drainage area is often represented by a power law relationship, which is commonly expressed as SDR is directly proportional to a^{-b}, where b is an exponent. So, it suggests that sediment delivery ratio varies inversely with the drainage area, and of course, with an exponent. So, the correct option B, that is SDR varies inversely with $A^{0.2}$, is the correct answer.



Then we move to question number 20 from module 8. The primary output of a hydrological model is monthly average temperature, stream flow hydrograph, ocean salinity, or wind direction? We know that the primary output of a hydrological model can vary depending on the specific goals and components of the model. So, different components can have different goals. However, one of the key outputs that is often of interest is the stream flow hydrograph, which consists of a time series graph showing variation of discharge over a specific time period, often on daily or monthly basis. So, that is a typical thing. Otherwise, also we know that in rainfall-runoff transformation process, the primary goal of hydrology, and that is how hydrological models also look at it. So, basically, option B, that is stream flow hydrograph, is the correct answer for this particular question.

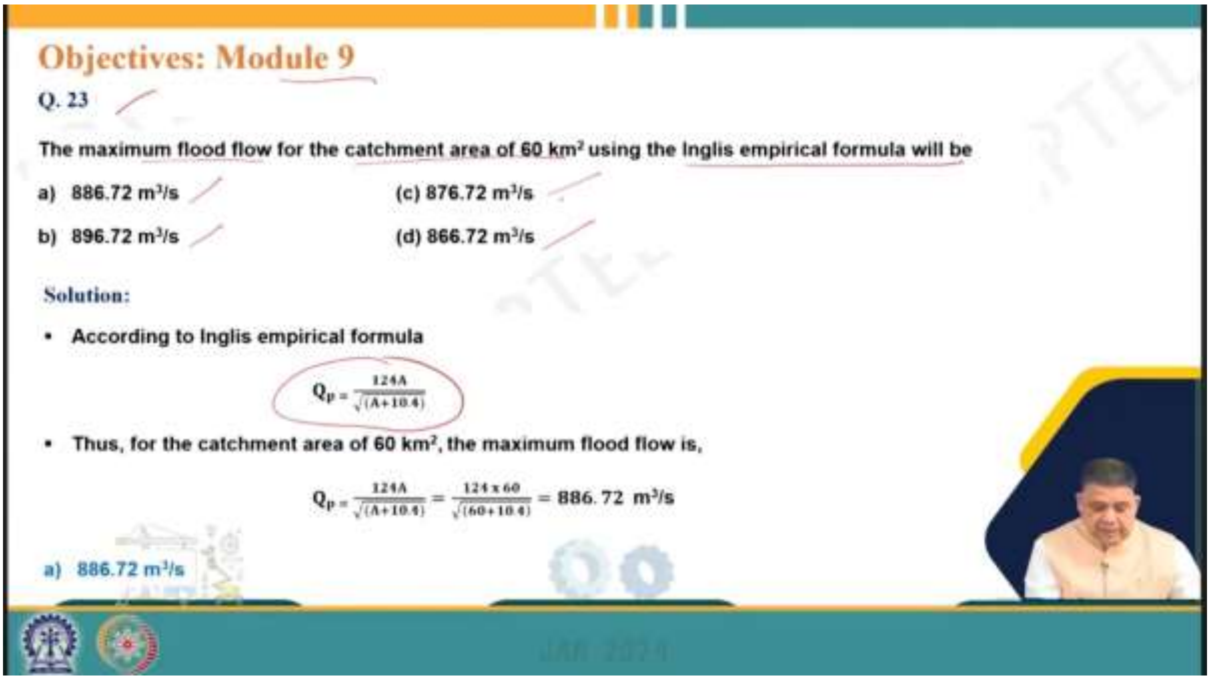


We go to question number 21. What is the primary purpose of hydrological modelling? To control flood events, to simulate the movement of glaciers, to predict precipitation patterns, or to understand and manage water-related processes? We know that the primary purpose of hydrological modelling is to understand and simulate the movement, distribution, and behaviour of water within a specific area, typically a watershed or river basin. Hydrological models are used to represent and analyse various processes related to the water cycle, providing insights into the availability, distribution, and movement of water resources. So, on a larger goal, we can say the primary purpose of hydrological modelling is to understand and manage water-related processes. That is option B, is the correct answer.

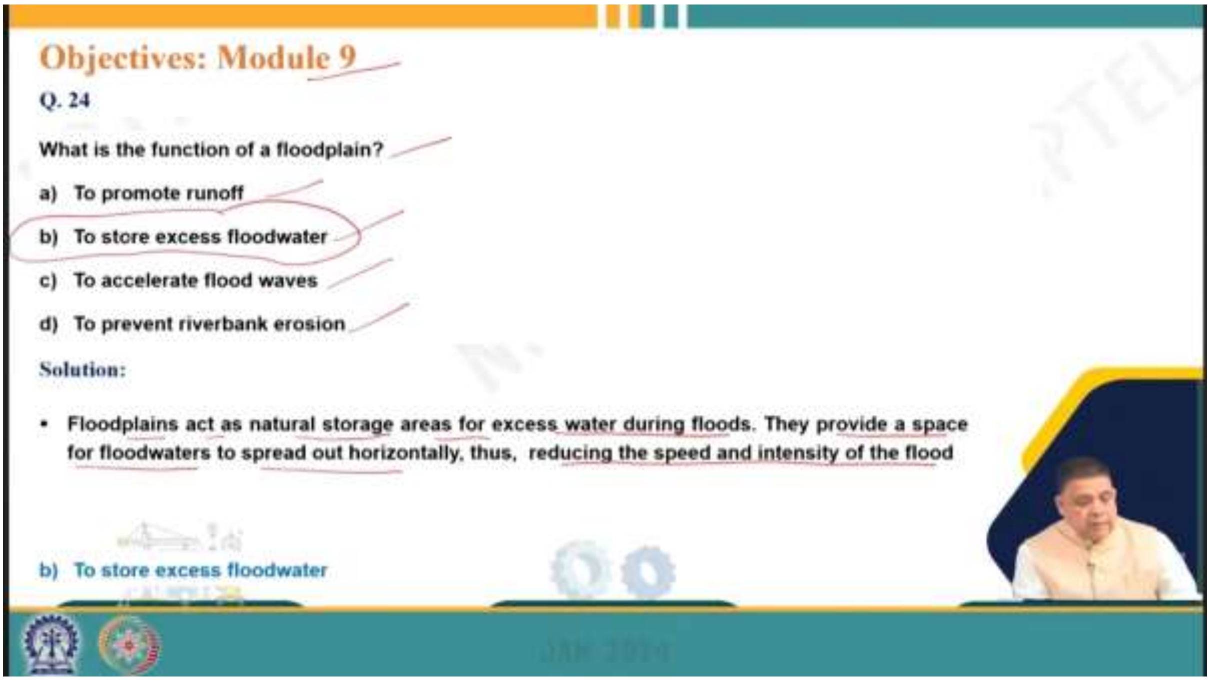


Now, we go to question number 22, again in module 8. The primary purpose of calibration of hydrological modelling is to maximize water extraction from rivers, to estimate the economic value of water resources, to validate the accuracy of meteorological data, or to improve the model's representation of observed hydrological behaviour. If you remember, we discussed calibration validation in great detail. So, if you remember, model calibration involves adjusting the model parameters to improve its ability to simulate observed hydrological processes within a watershed. So, we play with the hydrological model parameters so that we get a correct match of measured and simulated values. So, the goal is to minimize the discrepancies between model predictions and actual measurements of stream flow, precipitation, evapotranspiration, or other relevant variables.

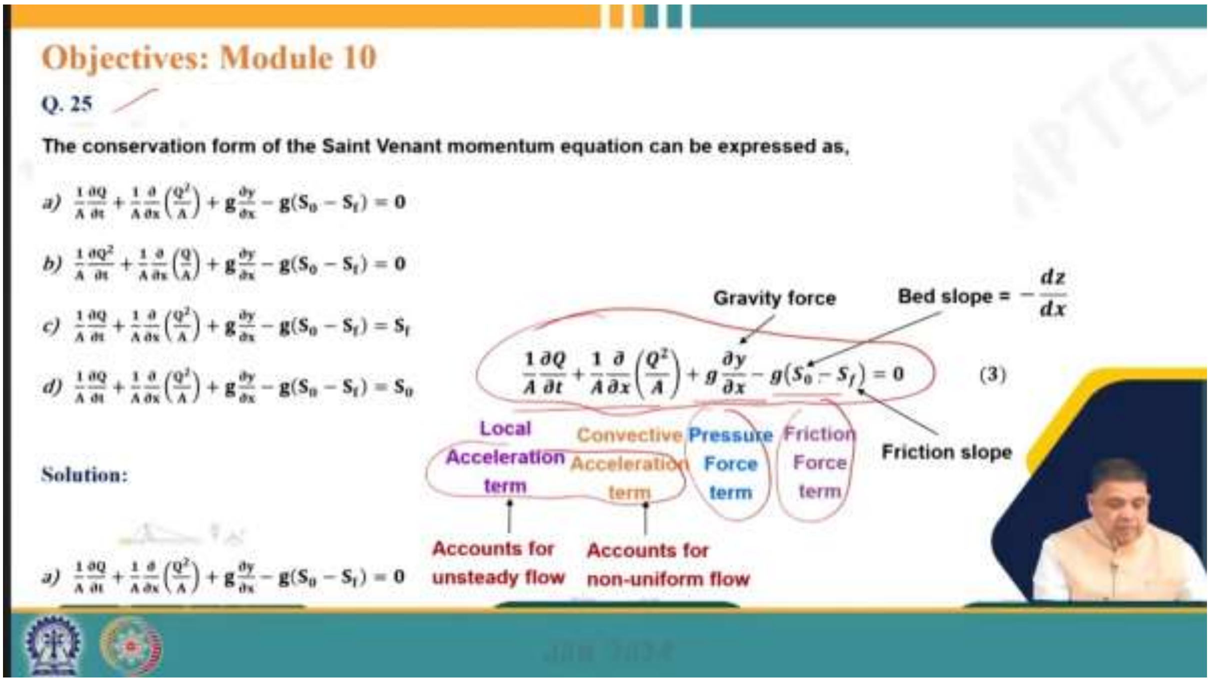
So, basically, option D, which is to improve the model's representation of observed hydrological behaviour, is the primary purpose of calibration in hydrological modelling.



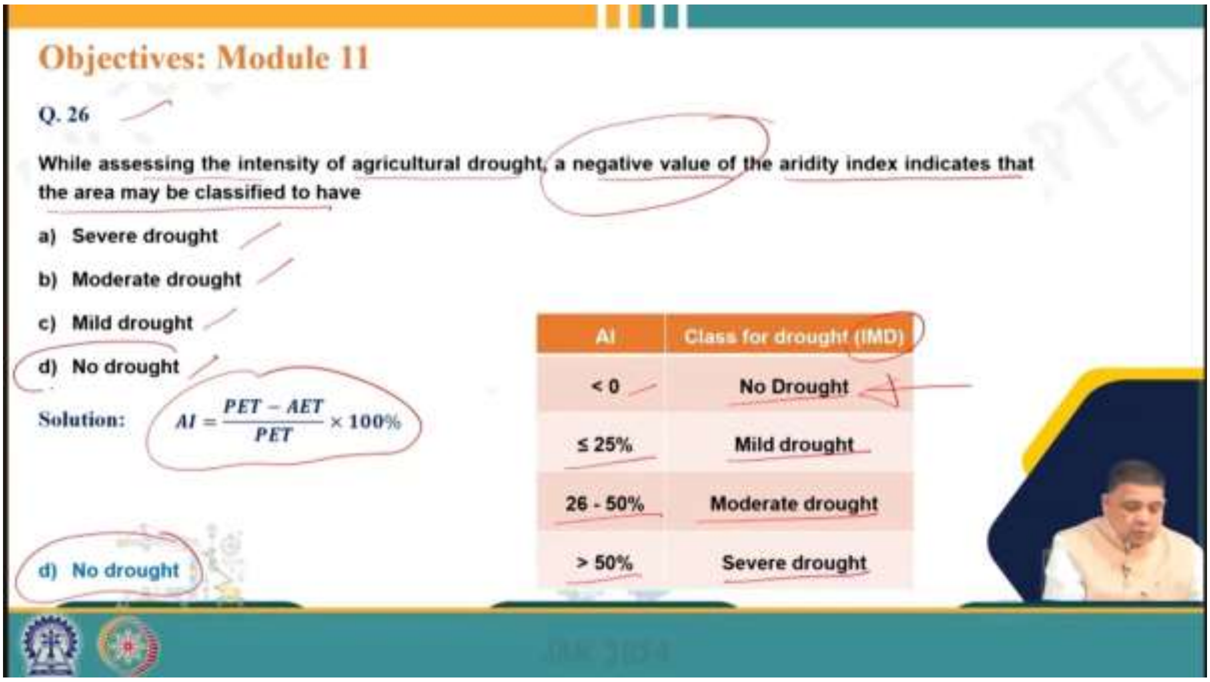
Moving on to question number 23, which is from module 9. The maximum flood flow for a catchment area of 60 square kilometers using the English empirical formula will be 886.72, 896.72, 876.72, or 866.72 cubic meters per second. It is basically an application of the English empirical formula, which is given by $Q_p = \frac{124A}{\sqrt{(A+10.4)}}$. The only variable here is aa, which is given as 60 square kilometers. So, by putting the value of aa as 60, we get a Q_p value of 886.72 cubic meters per second. Therefore, option a is the correct answer to this particular question.



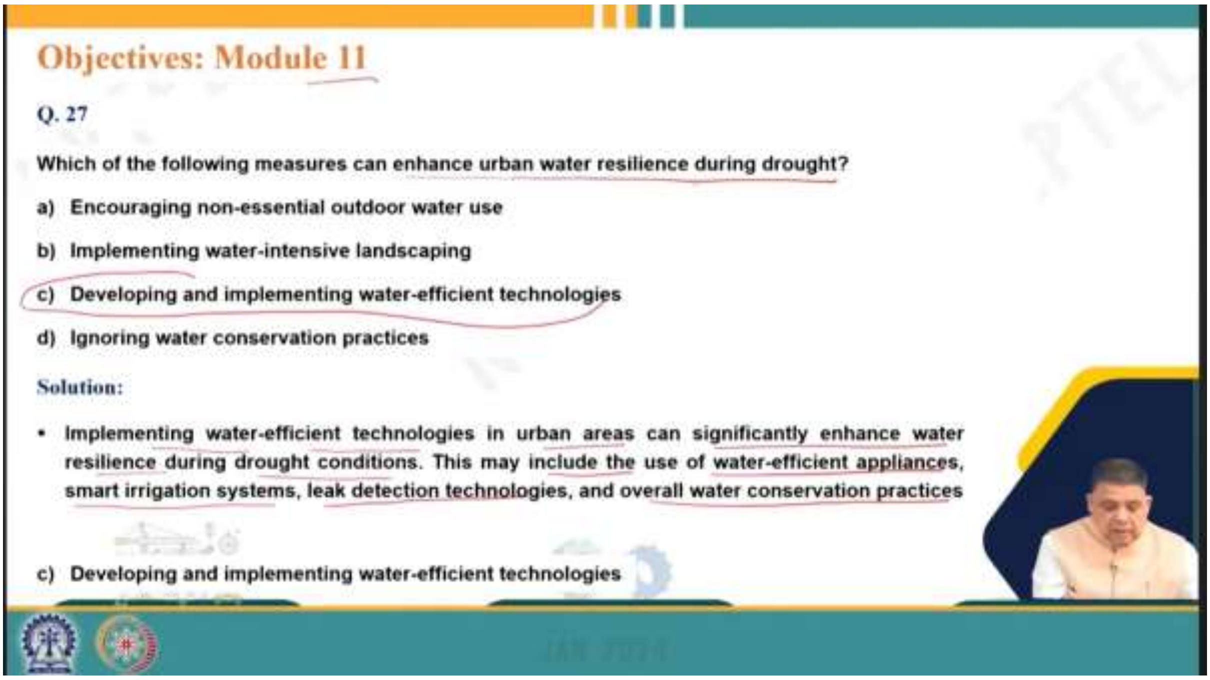
Then we move to question number 24. What is the function of a floodplain? This is from module 9. The options are to promote runoff, to store excess floodwater, to accelerate flood waves, or to prevent riverbank erosion. If you remember, floodplains act as natural storage areas for excess water during floods. They provide space for floodwaters to spread out horizontally, thus reducing the speed and intensity of floods. So, basically, option B, to store excess floodwater, is the major function of floodplains and is the correct option.



Next, we have question number 25. The conservation form of the Saint Venant momentum equation can be expressed in four different equations given here as partial differential equations. As we know, the Saint Venant equations are like that. Basically, if you remember, the conservation form of the equation is given by this relationship, and you also remember that this has different terms: a friction force term, a pressure force term, and two acceleration terms, local and convective, as well as terms for bed slope and friction slope. So, matching this, we find that option A is the correct answer to this particular question.



Then we move to question number 26. While assessing the intensity of agricultural drought, a negative value of the aridity index indicates the area may be classified to have severe drought, moderate drought, mild drought, or no drought. These are the options here. We know that the aridity index is given by this relationship: AI=$\frac{PET-AET}{PET}$ x100%. As far as the class of drought defined by IMD is given by this table, if it is less than 0, it's no drought; less than or equal to 25 percent, it's mild drought; 26 to 50 percent, it's moderate drought; and greater than 50 percent, it's severe drought. Because we have a negative value of the aridity index, that means we belong to the "no drought" class. Therefore, option D, which is "no drought," is the correct answer.



Finally, we have question number 27 from module 11. Which of the following measures can enhance urban water resilience during drought? The options are encouraging non-essential outdoor water use, implementing water-intensive landscaping, developing and implementing water-efficient technologies, and ignoring water conservation practices. We discussed this in detail, stating that implementing water-efficient technology in urban areas can significantly enhance water resilience during drought conditions. This may include the use of water-efficient appliances, smart irrigation systems, leak detection technology, and overall water conservation practices—anything technological development that can lead to water savings. So, that means developing and implementing water-efficient technologies is the correct option for this particular question.

So, with this, we come to the end of this lecture. Thank you very much for your attention. Please feel free to give your feedback and also raise any questions or doubts. We shall be happy to answer them on the forum. Thank you.


THANK YOU