Project Time Planning

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What is Planning

- The Development of a workable program of operations to accomplish established objectives when put into action.
- Done before project starts
- Planning for:
  - Construction process
  - Jobsite safety
  - Jobsite layout
  - Workforce

Who Needs Planning

- Owner
- Designer
- Contractor
  - Pre-tendering planning
  - Project Planning

Benefits of Planning

- Savings:
  - Cost
  - Time
- Quality improvements
- Avoided problems
- Solved problems

Problems Caused By Not Planning

- Additional costs
- Project delays
- Conflicts with other parties
- Quality problems

Result of “Day-to-Day” Planning

- ❑Wasted time;
  - ❑Labor cost, Longer construction time
- ❑ Possible rework
  - ❑ Not anticipating future work
  - ❑Cost and time impact
- ❑ Inadequate project quality
- ❑ Conflicts between subcontractors
- ❑ Safety planning gets overlooked

Program Evaluation and Review Technique [PERT]

Program Evaluation and Review Technique (PERT)

VS

Critical Path Method (CPM)

Critical Path Method (CPM)

- CPM used a single time estimate for each activity.
- This is because, in construction, each activity is "deterministic" in the sense that similar or identical work has been performed many times before.

Critical Path Method (CPM)

- The single time estimate of the activity completely ignores the chance of variability associated with the conduct of the project activities.
- Sources of variation include weather, equipment failure, personnel or materials problems, or uncertainties in the method or procedures to be used in carrying out the activity.

Program Evaluation and Review Technique (PERT)

- PERT is appropriate for scheduling and controlling research and development type projects, or others comprised of activities whose actual duration times are subject to considerable chance of variation (random variation).

Program Evaluation and Review Technique (PERT)

- Advantage of the PERT statistical approach is that it offers a method of dealing with this chance variation, making it possible to allow for it in the scheduling calculations, and finally using it as a basis for computing the probability (index) that the project, or key milestones in the project, will be completed on or before their scheduled dates.

Program Evaluation and Review Technique (PERT)

- Probability has already been defined as a way of measuring uncertainty.
- PERT uses three time estimates for each activity
- This is a "probabilistic" approach that lends itself to activities for which there is no historical record of experience.

Program Evaluation and Review Technique (PERT)

- PERT uses three time estimates for each activity:

1) an optimistic or minimum time,
2) a most likely or modal time,
3) a pessimistic or maximum time.

Optimistic Time (a/T_o)

- Is the time which would be bettered only one time in twenty if the activity could be performed repeatedly under the same essential conditions.
- The activity is executed under very favorable conditions.
- The probability of being completed within this duration is about 0.05. (optimistic time = short time)

Pessimistic Time (b/ Tp)

- Is the time which would be exceeded only one time in twenty if the activity could be performed repeatedly under the same essential conditions.
- The activity is performed under very unfavorable conditions.
- The probability of its occurrence is about 0.05. (pessimistic time = long time)

Most Likely Time (m/ Tm)

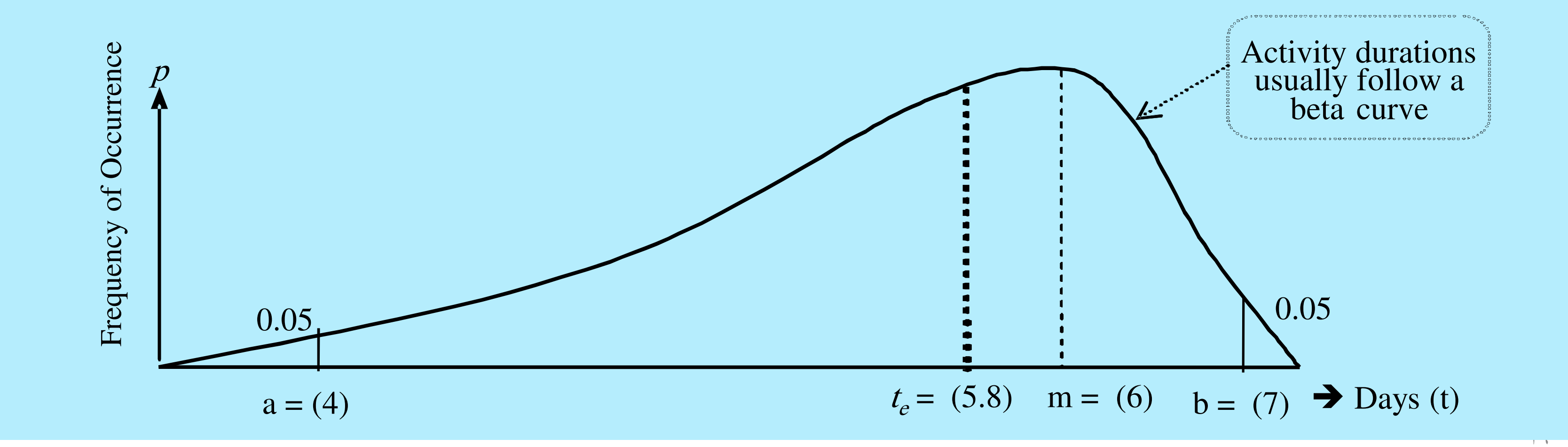
- Is the modal value of the distribution, or the value which is likely to occur more often than any other value.
- Usually closet to the actual durations. Very high probability.

The mean, expected, activity duration (te)

- Using three times estimate, the expected time, t_e, is computed.
- t_e is used as the best available time approximation for the activity in question.
- ***Mean = t_e = (a + 4m + b)/ 6***
- Where,
  - ***a*** = optimistic time,
  - ***m*** = most likely time,
  - ***b*** = pessimistic time.

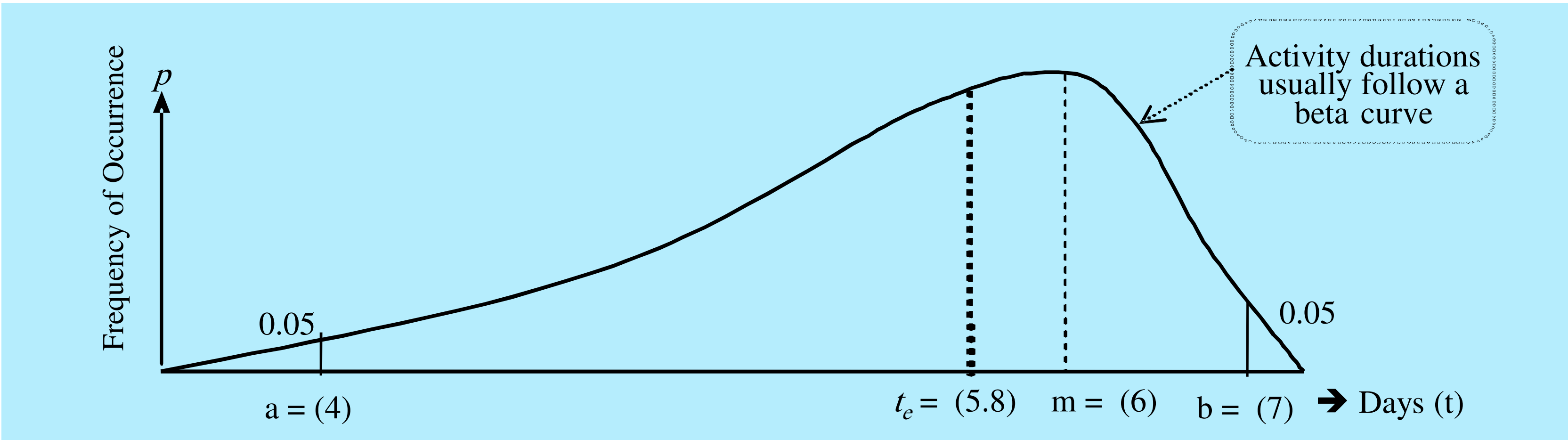
Probability of the Three Activity Duration Times

1) If an activity is performed a large number of times and record of the actual durations is maintained, a plot of frequencies of such durations will give the beta-curve (an unsymmetrical curve).



Probability of the Three Activity Duration Times

- $(t \leq a)$ p (a) = 0.05 = p (4)
- $(t \geq b)$ p (b) = 0.05 = p (7)
- $(t \leq m)$ p (m) = High = p (6)



Probability of the Three Activity Duration Times

2) Because the vertical line drawn at the most likely time ($m = 6.0$) does not divide the area under the curve into two equal parts, the probability of completing this activity in six time units is not 0.5.

Probability of the Three Activity Duration Times

3) $t_e = (a + 4m + b)/6 = (4 + 4*6 + 7)/6 = 5.8$.

4) t_e divides the area under the beta curve into two equal parts.

Probability of the Three Activity Duration Times

5) The probability that the activity will be finished in the t_e of 5.8 units is 0.5

6) t_e represents a points at which there is a 50-50 chance that the actual activity completion will be earlier or later that t_e.

Measures of Central Tendency and dispersion

- In PERT computations, arithmetic mean (t) and standard deviation (σ (t)/ (st)) will be denoted by t_e and (Vt)1/2, respectively; t approaches te and st approaches (Vt) $^{1/2}$, as the size of the sample, n, approaches infinity.

Measures of Central Tendency and dispersion

- Measure of central tendency = arithmetic mean = $\bar{t}$ = t_e
- **Mean = t_e = (a + 4m + b)/ 6**
- Measure of variability = standard deviation = σ (t) = st = $(Vt)^{1/2}$
- $(Vt)^{1/2}$ = **σ (t_e) = (b-a)/3.2**

Measures of Central Tendency and dispersion

- σ^2 (t) = st^2 = variance of t = (Vt).
- **Vt = σ^2 (te) = $[(b-a)/3.2]^2$**
- The variance describes the uncertainty associated with the time-estimating process.
- If the variance is large, there is a great uncertainty about when the activity will be completed.
- If the variance is small, so is the uncertainty.

Project Duration

- When t_e has been determined for each activity, project duration (T_E) and float can be determined from t_e by forward and backward passes as in a CPM network.

Project Duration

- Since the probability is 0.5 that each activity will finish at its expected time t_e, there is a probability of 0.5 for the entire project being finished at time T_E.

Project Duration

- The expected project duration times do not follow a beta curve but follow a normal distribution curve; therefore the expected project durations may be assumed normally distributed.

PERT Computations

1. Calculate expected activity duration (t_e)
   - $t_e = (a + 4m + b)/6$

- where
- a = Optimistic duration
- m = most likely duration
- b = pessimistic duration

PERT Computations

2. Calculate standard deviation of an activity $(v_t)^{1/2} = (\sigma\ t_e)$
   - $(v_t)^{1/2} = \sigma\ (t_e) = (b - a)/\ 3.2$

3. Calculate variance of an activity (v_t)
   - $(v_t) = \sigma^2\ (t_e) = [(b - a)\ /3.2]^2$

4. Do CPM analysis, using 't_e' as activity times.

PERT Computations

5. Identify critical activities with activities times "t_e^*"

6. Calculate project time (T_e)
   - $T_e = \sum t_e^*$

PERT Computations

7. Calculate project variance (V_T) = σ^2 (T_e)

- $V_T = \sigma^2 (T_e) = \sum \sigma^2 (t_e^*)$

❑ For multiple critical paths, consider the highest total of variances.

8. Calculate project standard deviation $(V_T)^{1/2}$ = σ (T_e)

- $\sigma (T_e) = (V_T)^{1/2}$ or $\sigma (T_e) = \sqrt{(V_T)}$

Probability of Meeting a schedule Date

The following steps should be considered when computing the probability of occurrence of an event, on or before a scheduled time.

Probability of Meeting a schedule Date

1. Make the usual forward and backward pass computations based on a single-time estimate, t_e , for each activity.

Probability of Meeting a schedule Date

2. Suppose one wishes to compute the probability of meeting a specified scheduled time for event *X*. Then determine the "longest path" from the initial event to the event *X*.

Probability of Meeting a schedule Date

3. Compute the variance for event *X*, (V_T), by summing the variances for the activities listed in Step 2. V_T = sum of values of $[(b-a)/3.2]^2$, for each activity on the "longest path" leading to event X.

Probability of Meeting a schedule Date

4. Compute Z using the following equation and look up the corresponding probability in the normal curve table.

$$P\{T \leq T_S\} = P\{Z \leq z = [T_S - E(T)] / \sqrt{V_T}\}$$

Probability of Meeting a schedule Date

4. (cont.)

- A value of Z = 1.25 (e.g.) indicates that the scheduled time, T_S , is 1.25 standard deviations greater than the expected time, T_e .
- It is essential that the correct sign is placed on the Z.

Example

The basic information for a small research and development project is listed in the table below. Use PERT technique to answer the following questions:

Activity	Depends on	Time in Weeks		
		a	m	b
A	—	2	3	4
B	—	4	5	6
C	—	1	2	3
D	A	3	4	5
E	B	1	1	2
F	B	3	5	7
G	C	1	2	3
H	C	1	3	5
I	D & E	3	6	9
J	F & G	2	3	4

Example

1. Find the expected project duration **T_e** , and project standard deviation **σ_T**.
2. What is the probability of completing the work **in 15 weeks**?
3. What is the probability of completing the work **at 15 weeks**?
4. What is the probability of **not meeting** a deadline of 15 weeks?
5. What is the due date that will have **a 75%** chance of meeting ?

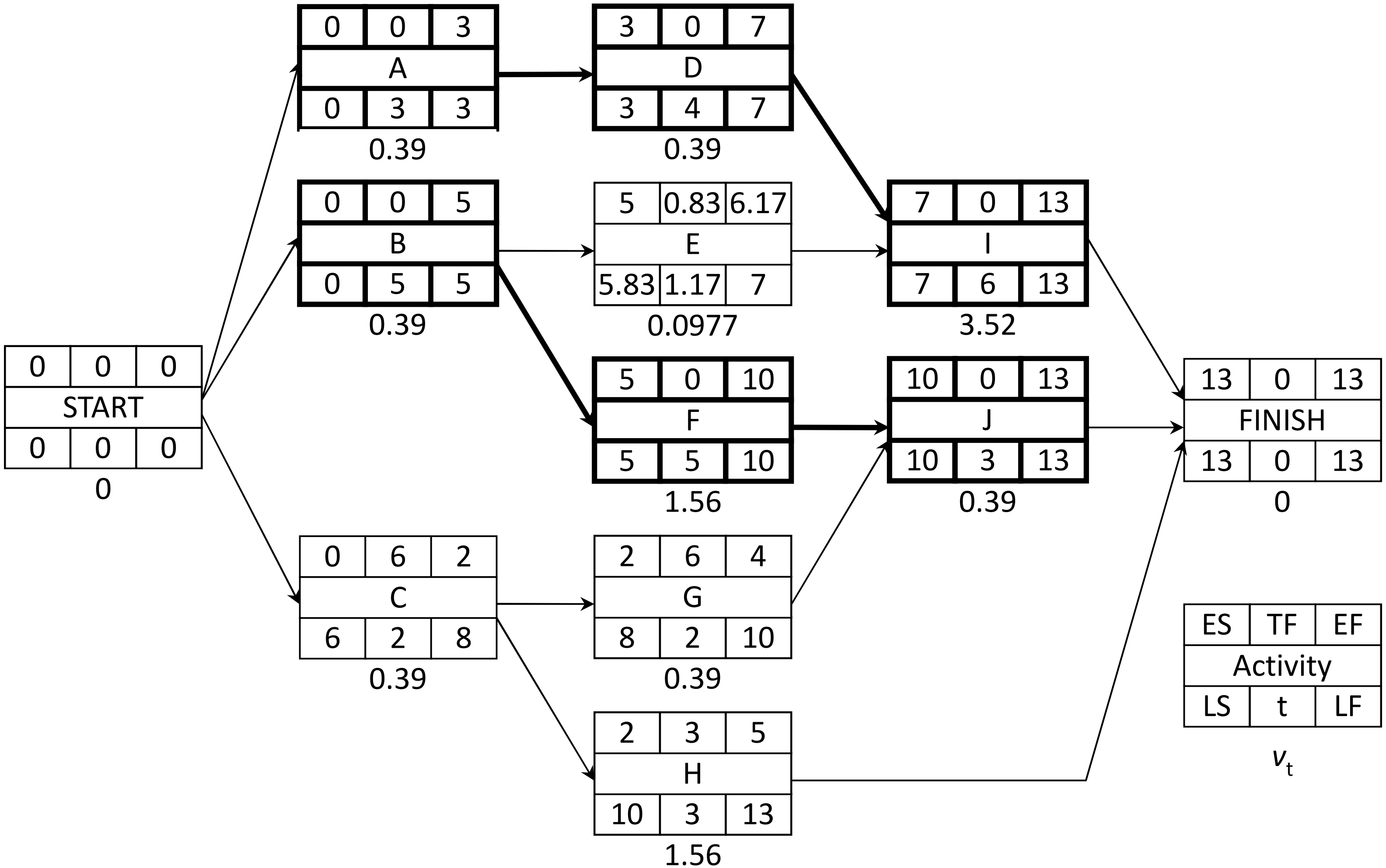
Example

6. What is the probability that **Activity I can start by week 8th**?
7. What is the probability of completing the project **between 10 weeks and 12 weeks**?
8. What is the probability of not completing the project **between 10 weeks and 12 weeks**?

Example

Activity	Depends on	Time in Weeks					
		a	m	b	t_e	σ_t	v_t
A	—	2	3	4	3	0.625	0.39
B	—	4	5	6	5	0.625	0.39
C	—	1	2	3	2	0.625	0.39
D	A	3	4	5	4	0.625	0.39
E	B	1	1	2	1.17	0.3125	0.0977
F	B	3	5	7	5	1.25	1.56
G	C	1	2	3	2	0.625	0.39
H	C	1	3	5	3	1.25	1.56
I	D & E	3	6	9	6	1.875	3.52
J	F & G	2	3	4	3	0.625	0.39

Example



0 0 0
START
0 0 0
0
0 0 3
A
0 3 3
0.39
0 0 5
B
0 5 5
0.39
0 6 2
C
6 2 8
0.39
3 0 7
D
3 4 7
0.39
5 0.83 6.17
E
5.83 1.17 7
0.0977
5 0 10
F
5 5 10
1.56
2 6 4
G
8 2 10
0.39
2 3 5
H
10 3 13
1.56
7 0 13
I
7 6 13
3.52
10 0 13
J
10 3 13
0.39
13 0 13
FINISH
13 0 13
0
ES TF EF
Activity
LS t LF
v_t

Example

1. Project time = $T_e = \sum t_e^*$
   - T_e = 3 + 4 + 6 = 13 weeks (the probability that the project will be finished in 13 weeks is 0.5 or $p(T \leq 13) = 0.5$.
   - Project variance $V_T = \sigma^2\,(T_e) = \sum \sigma^2\,(t_e^*)$
   - $V_T = 0.39 + 0.39 + 3.52 = 4.3$
   - $\sigma\,(T_e) = (V_T)^{1/2}\ \sigma_t = \sqrt{4.3} = 2.074$

Example

2. $P(\mathrm{T} < 15) = P(\mathrm{Z} < z = 15 - 13 / 2.074) = P(\mathrm{Z} < 0.9643) = 83.25\%$

3. $P(\mathrm{T} = 15), \Rightarrow \mathrm{Z} = z = 0.9643 = 83.25\%$

4. $P(\mathrm{T} > 15), \Rightarrow 1 - P(\mathrm{T} \leq 15) = 0.1675 = 16.75\%$

Example

5. $P(\text{T}) = 75\% \Rightarrow \text{Z}_{75\%} = 0.675 = \Rightarrow T_{75\%} = 0.675 \times 2.074 + 13$

- $\therefore$ z = 14.4 weeks

6. $\text{T}_\text{D} = 7$ weeks, $V_\text{D} = 0.39+0.39 = 0.78$, $\sigma_\text{D} = \sqrt{0.78} = 0.8832$

- $P(\text{T} \leq 8) = P(\text{Z} \leq z = 8 - 7 / 0.8832) = P(\text{Z} \leq 1.132) = 87.1\%$

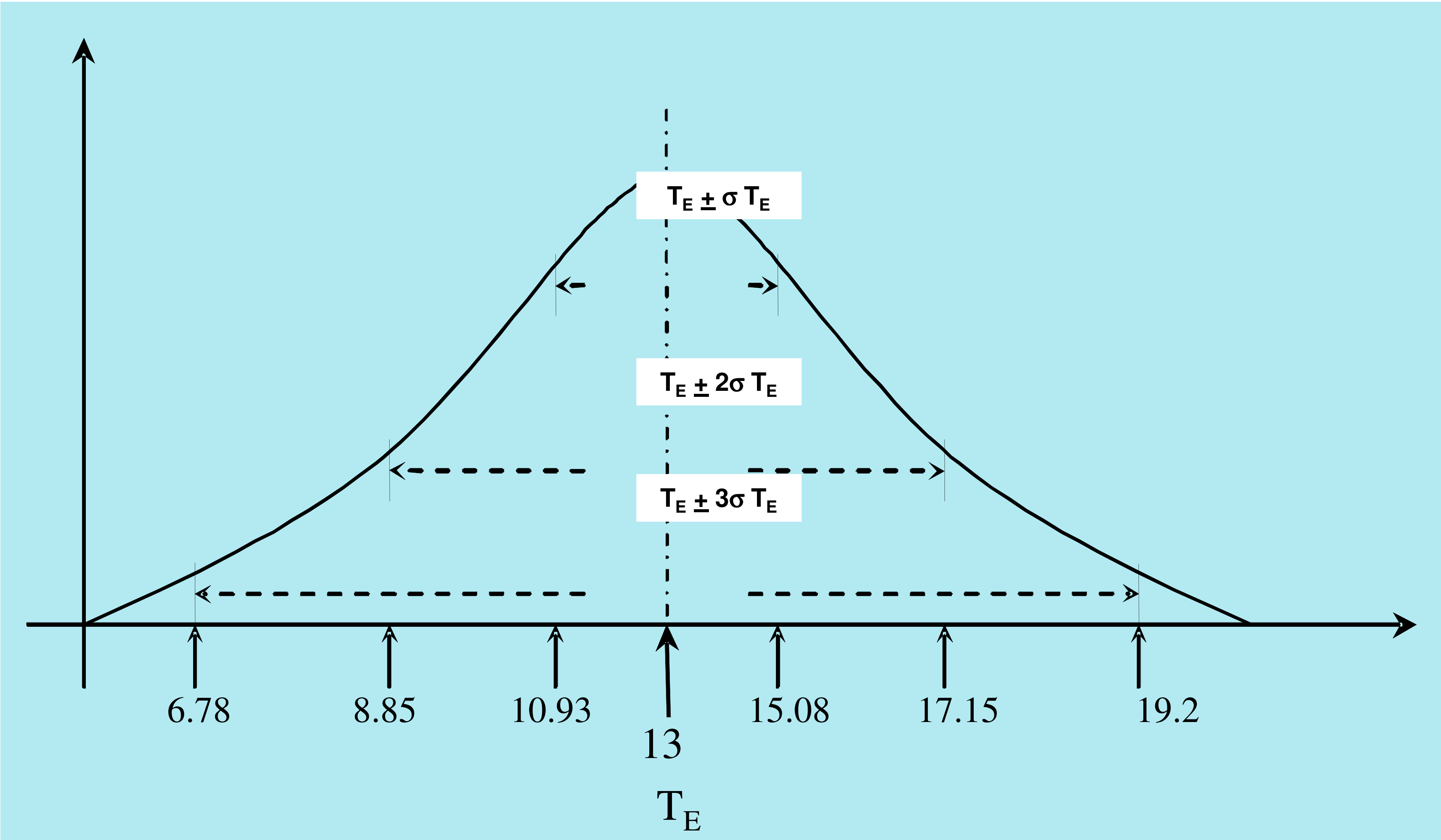
Example

7. $P(10 < T < 12), \Rightarrow P(T < 12) - P(T < 10) =$

- $P(Z < z = 12 - 13 / 2.074) - P(Z < z = 10 - 13 / 2.074)$
- $P(Z < -0.482) - P(Z < -1.447) = 0.3156 - 0.074 = 24.16\%$

8. $P(10 > T > 12) = 1 - P(10 < T < 12) = 1 - 0.2416 = 0.7584 = 75.84\%$

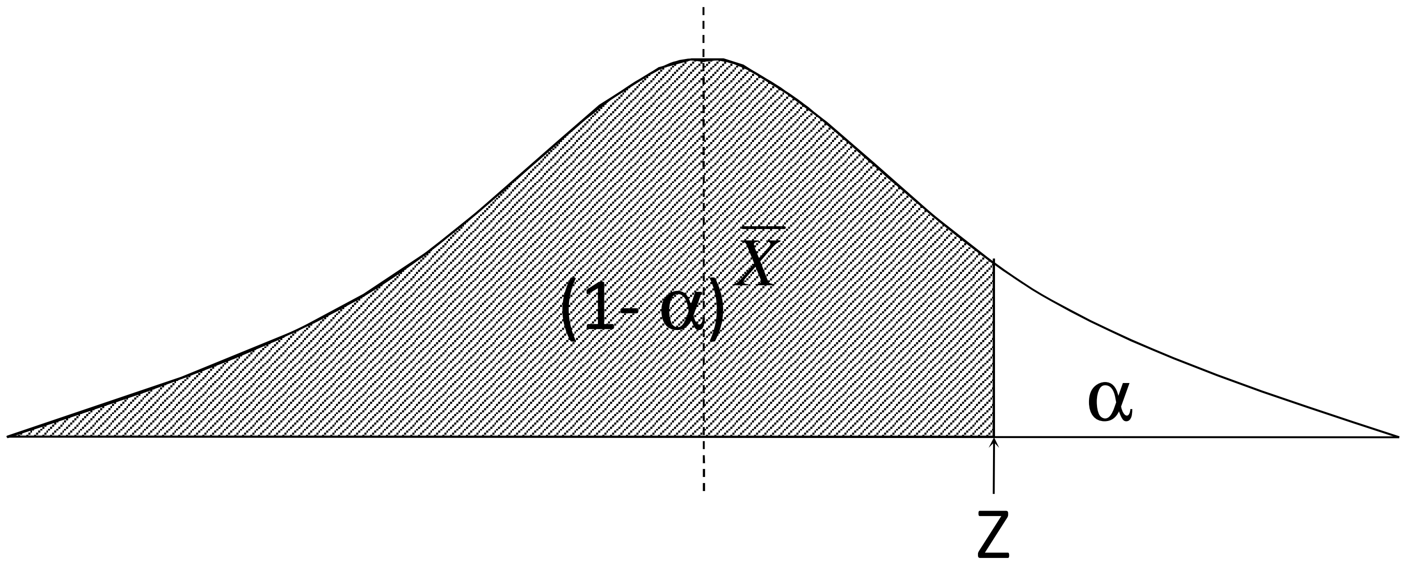
Example



$T_E \pm \sigma T_E$
$T_E \pm 2\sigma T_E$
$T_E \pm 3\sigma T_E$
6.78
8.85
10.93
13
T_E
15.08
17.15
19.2

Cumulative Probabilities of the Standard Normal Distribution

Entry is area 1- α under the standard normal curve from -∞ to z(1- α)



Cumulative Probabilities of the Standard Normal Distribution

z	**0.00**	**.01**	**.02**	**.03**	**.04**	**.05**	**.06**	**.07**	**.08**	**.09**
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.4878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952

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Thanks