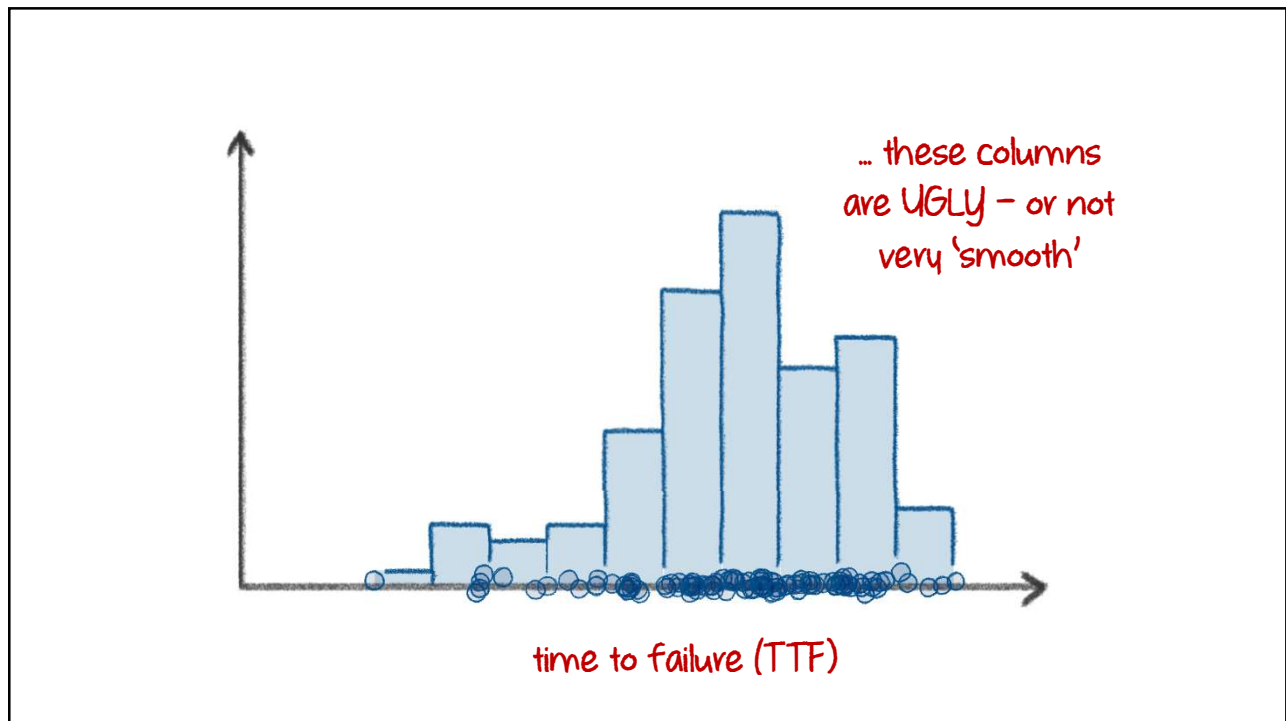
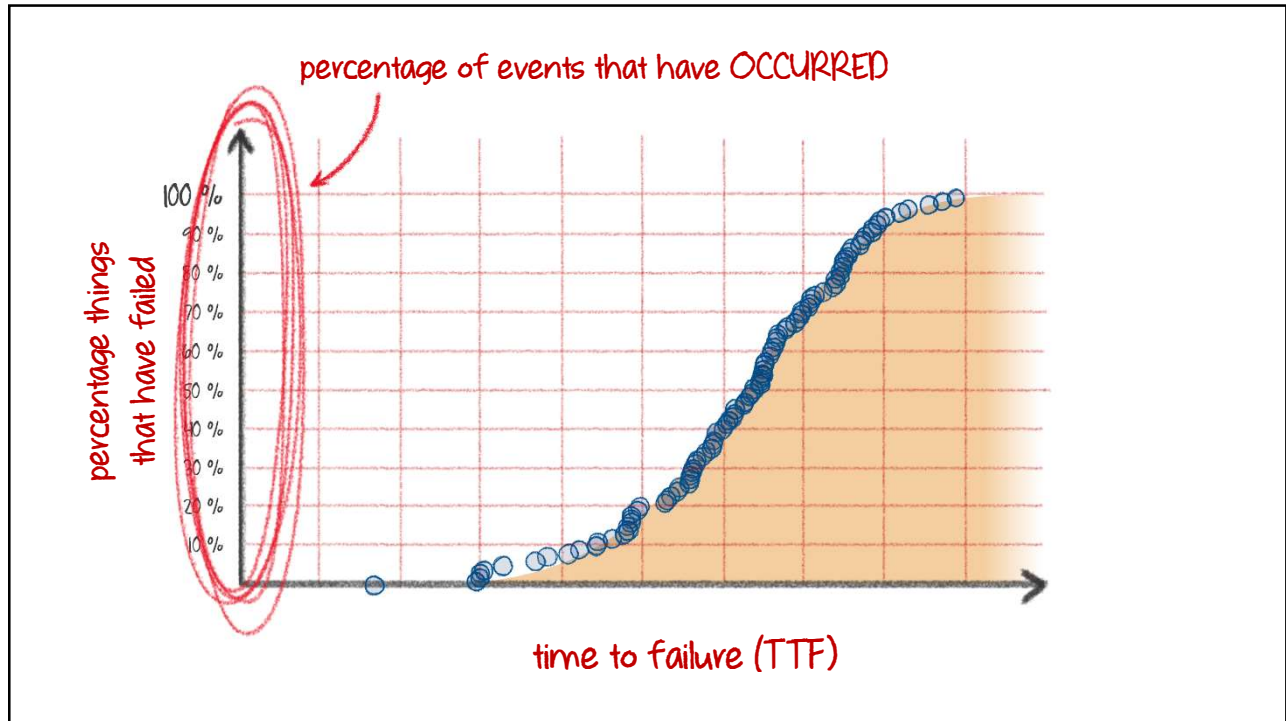


PDFs, CDFs, and other 'Fs' — what the hell are they?

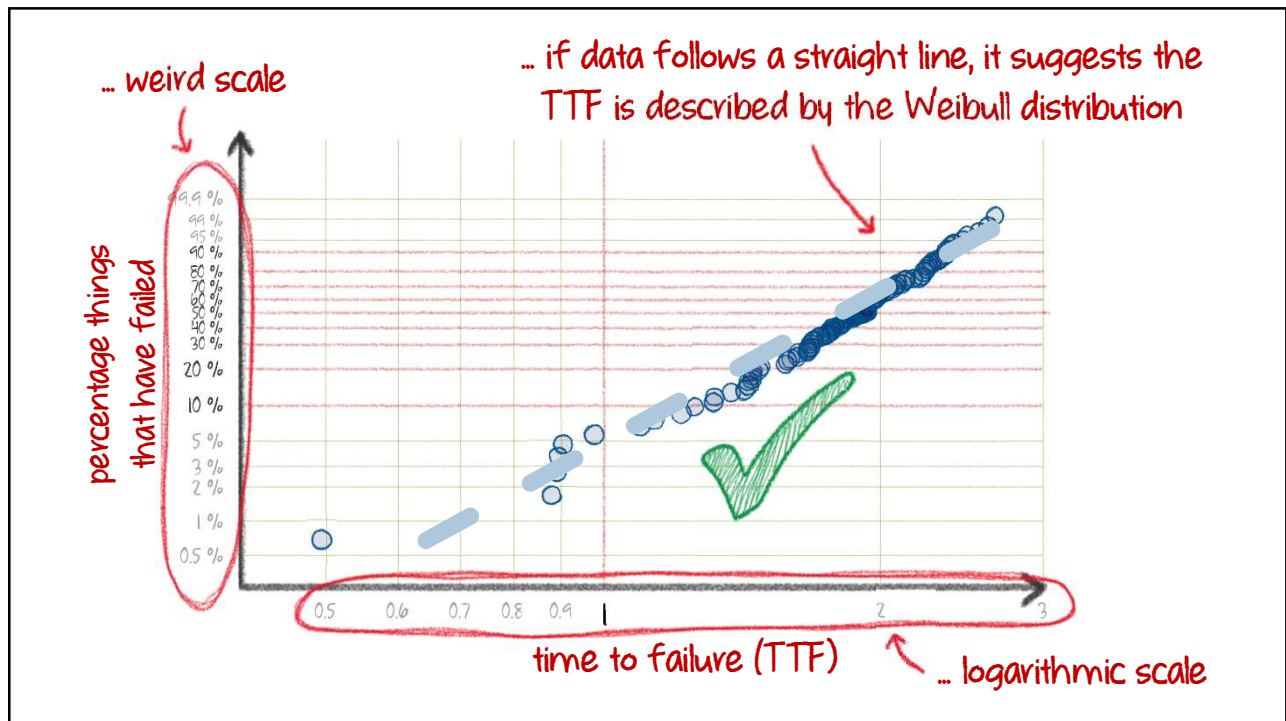
1



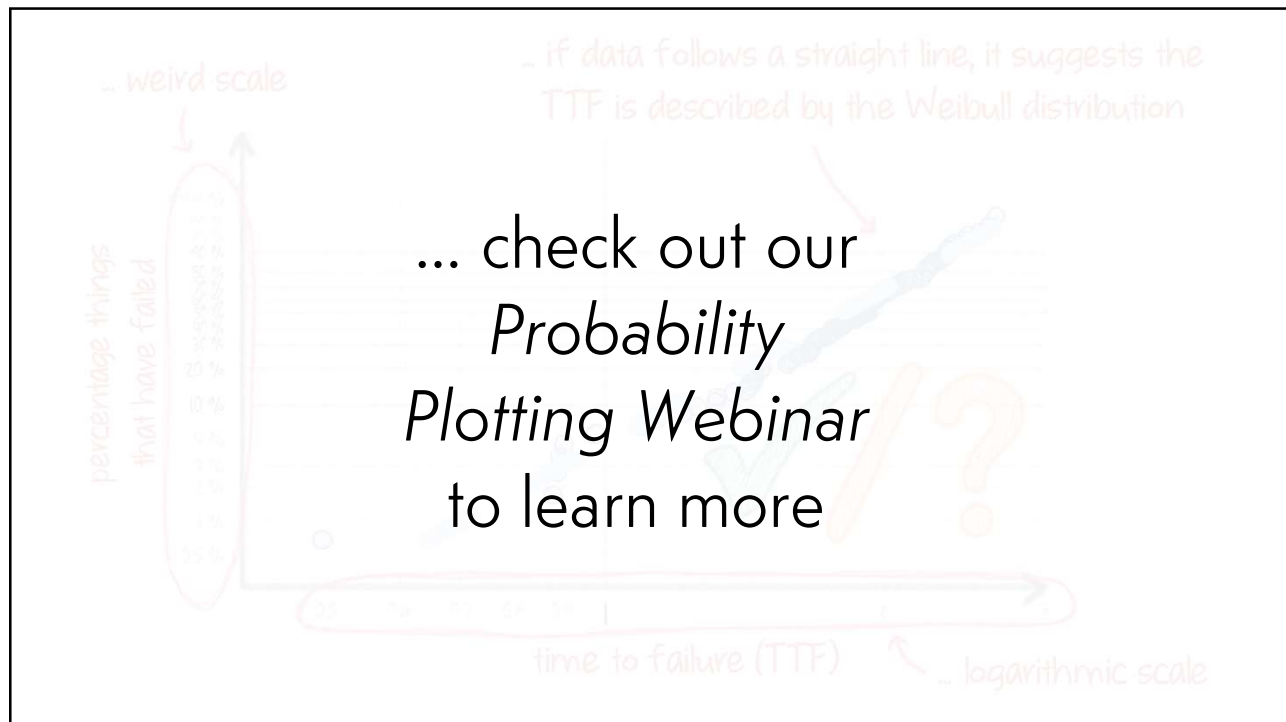
2



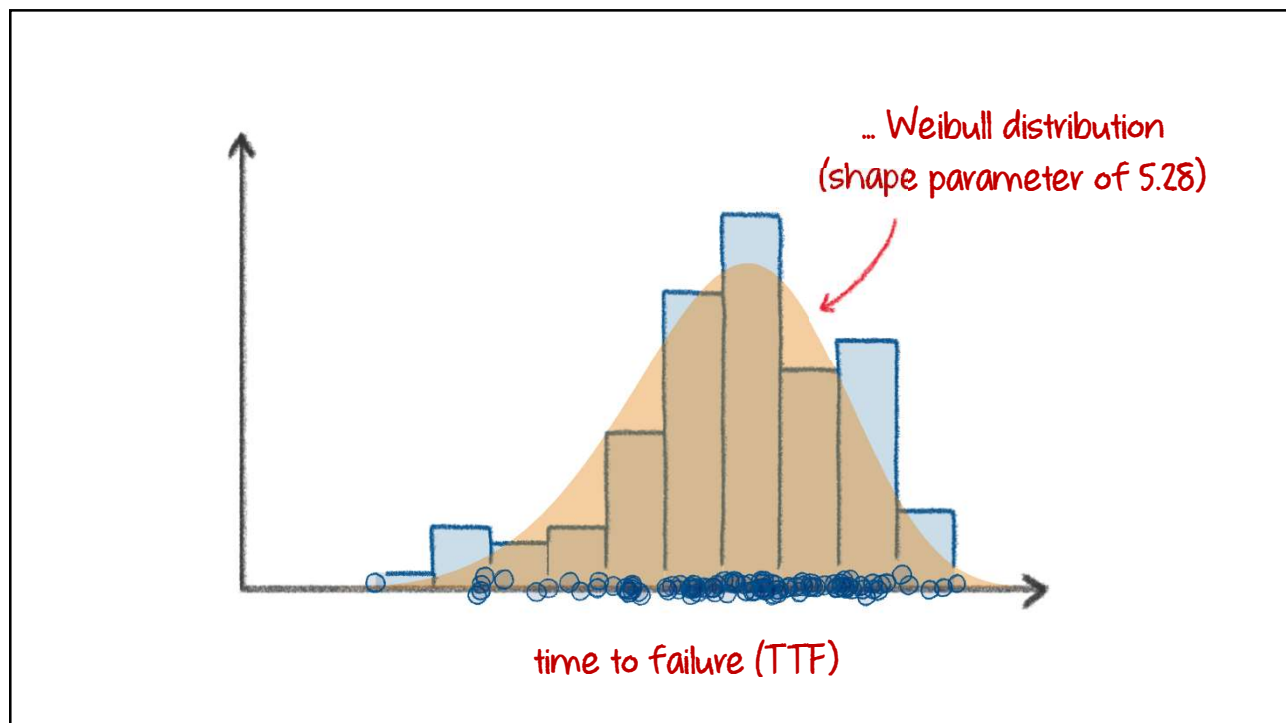
3



4



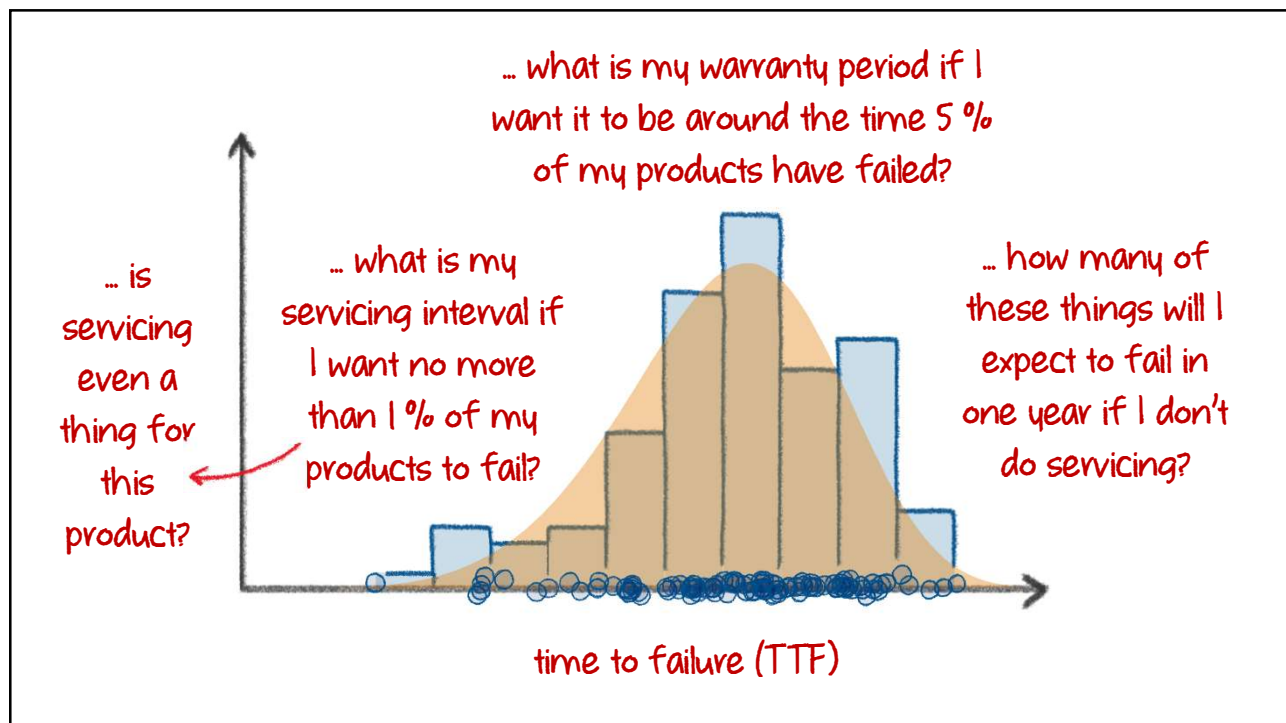
5



6

... random doesn't
mean *unpredictable*

7

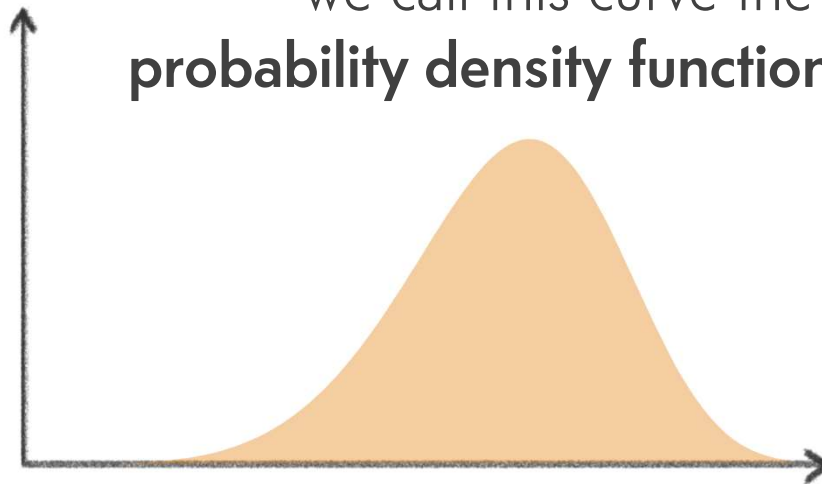


8

... our 'probability curve' can tell us all these things ...

9

we call this curve the
probability density function (PDF)

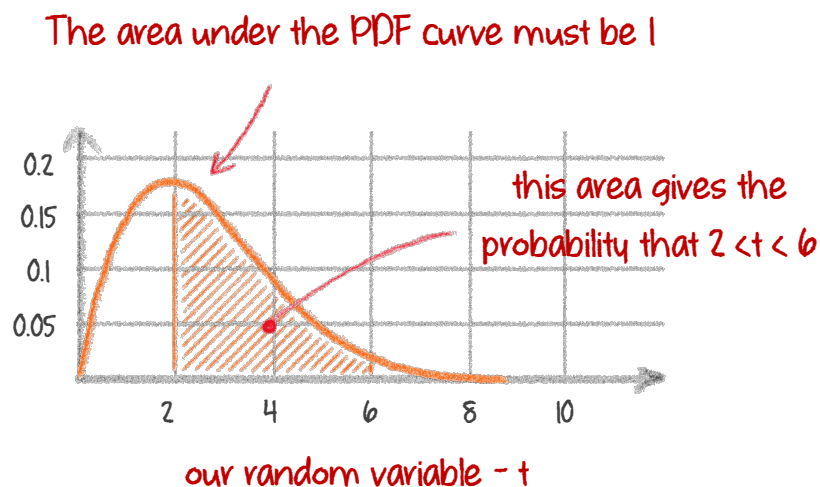


time to failure (TTF)

10

$f(x)$ or the
probability density function (PDF)
gives the relative probability
that a continuous random variable is
equal to a specific value

11

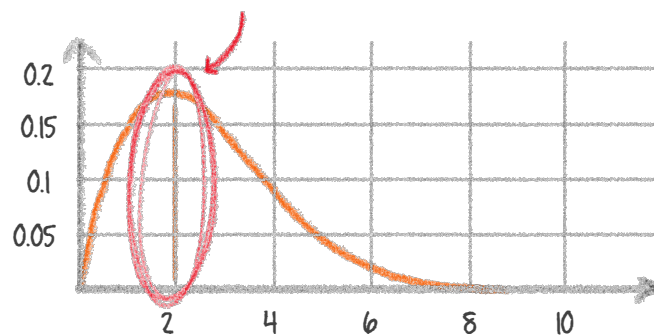


12

the values of our
probability density function (PDF)
curve have no *direct meaning* ...

13

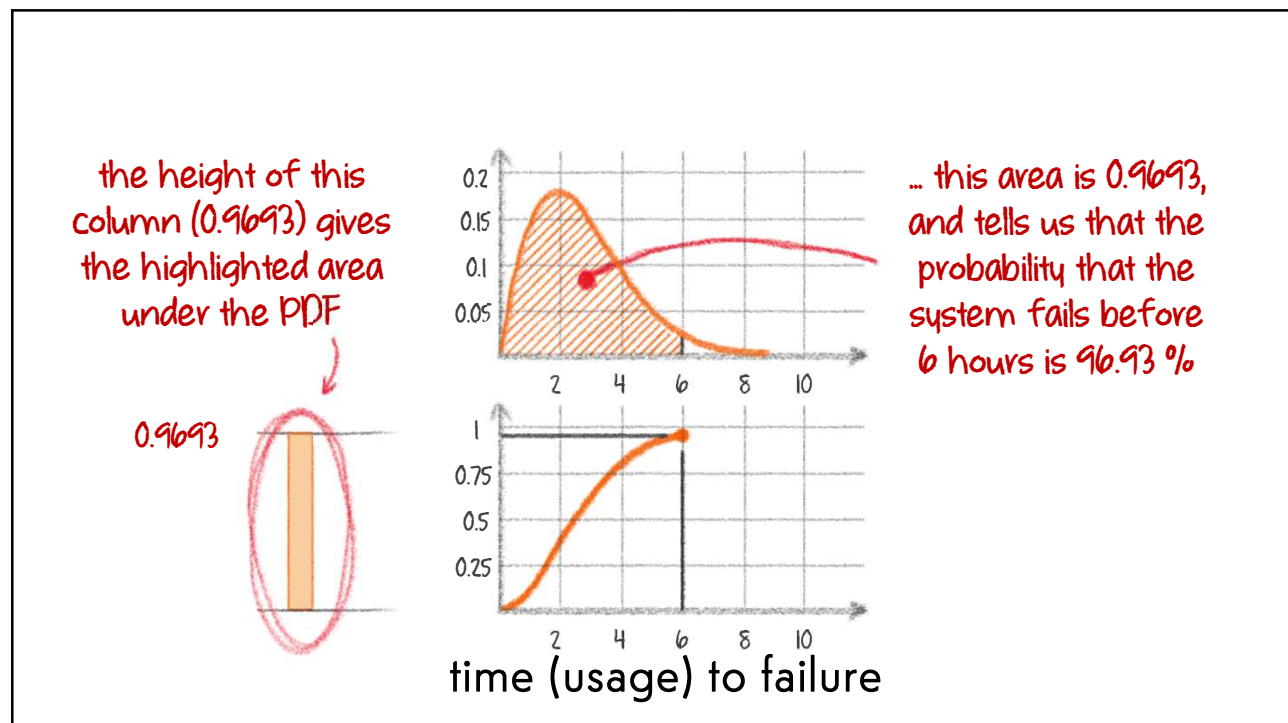
... the probability that $t = 2$ is this area here
... which is zero !!!



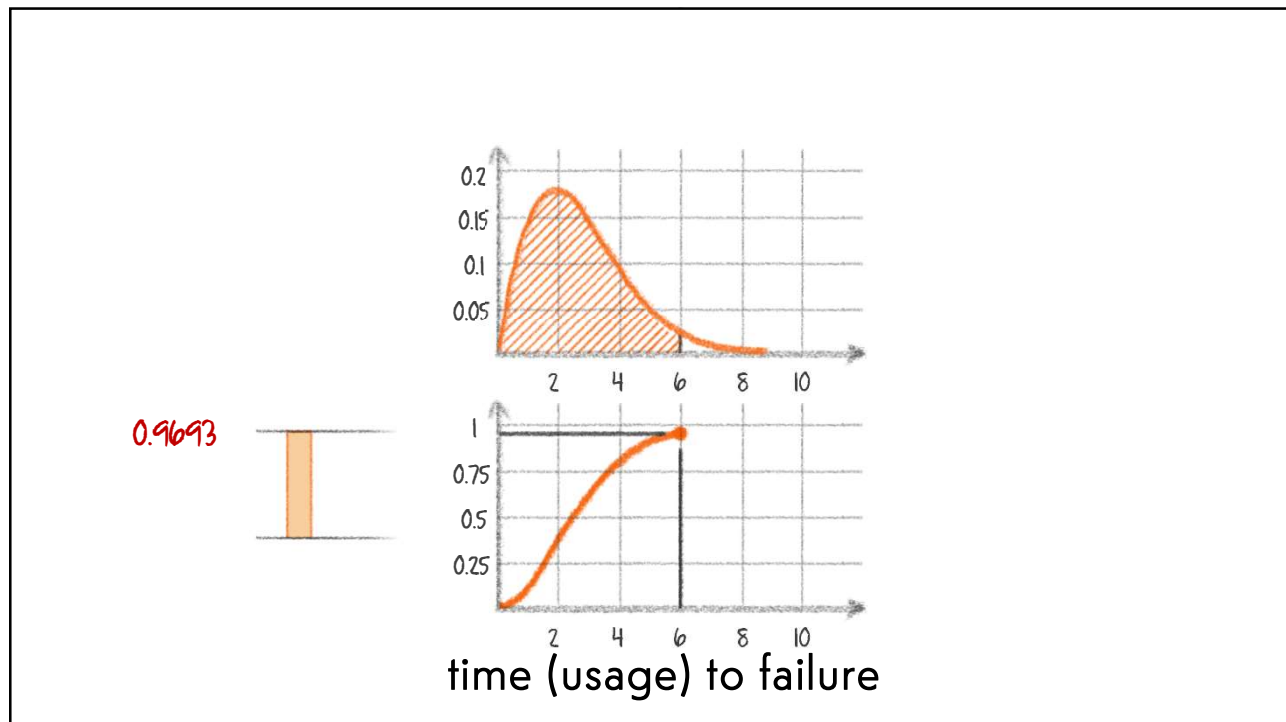
14

conceptually, the probability that
a continuous random variable can
take on a specific value is zero
... we must deal with intervals!

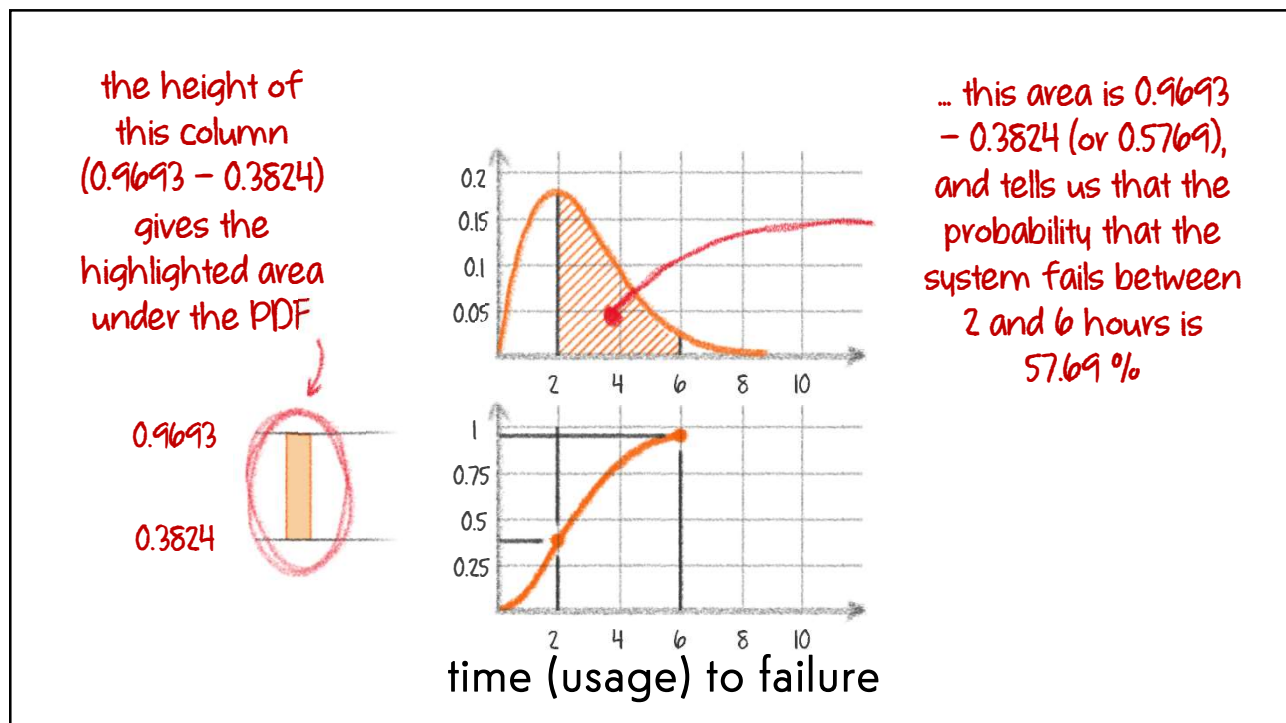
15



16

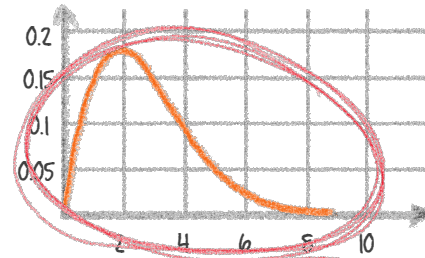


17

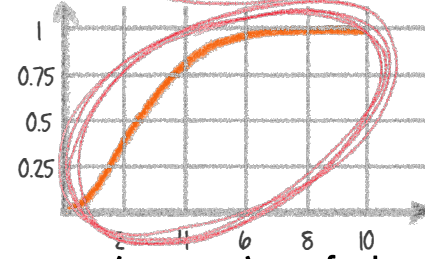


18

... this PDF curve
gives the slope of
the AREA curve



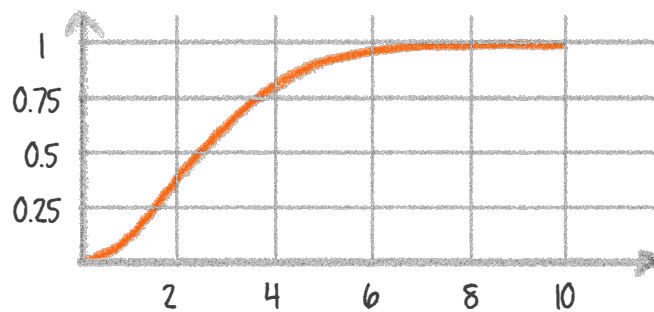
... this AREA curve
gives the areas under
the PDF curve



time (usage) to failure

19

... this AREA curve tells us the probability
that the random variable value is LESS
than the value on the horizontal axis



... or in reliability engineering, the
PROBABILITY THAT OUR PRODUCT OR
SYSTEM HAS FAILED

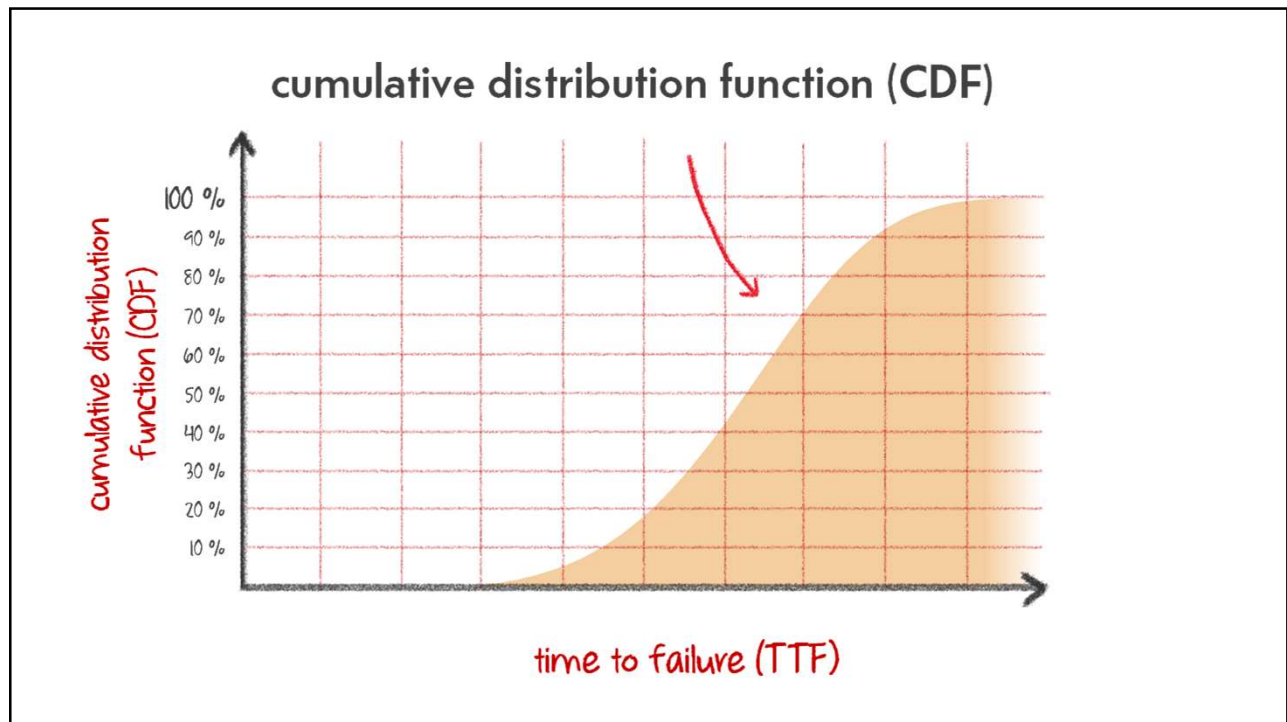
20

$F(x)$ or the
cumulative distribution function (CDF)
gives the probability that a random
variable is less than or equal
to a specific value.

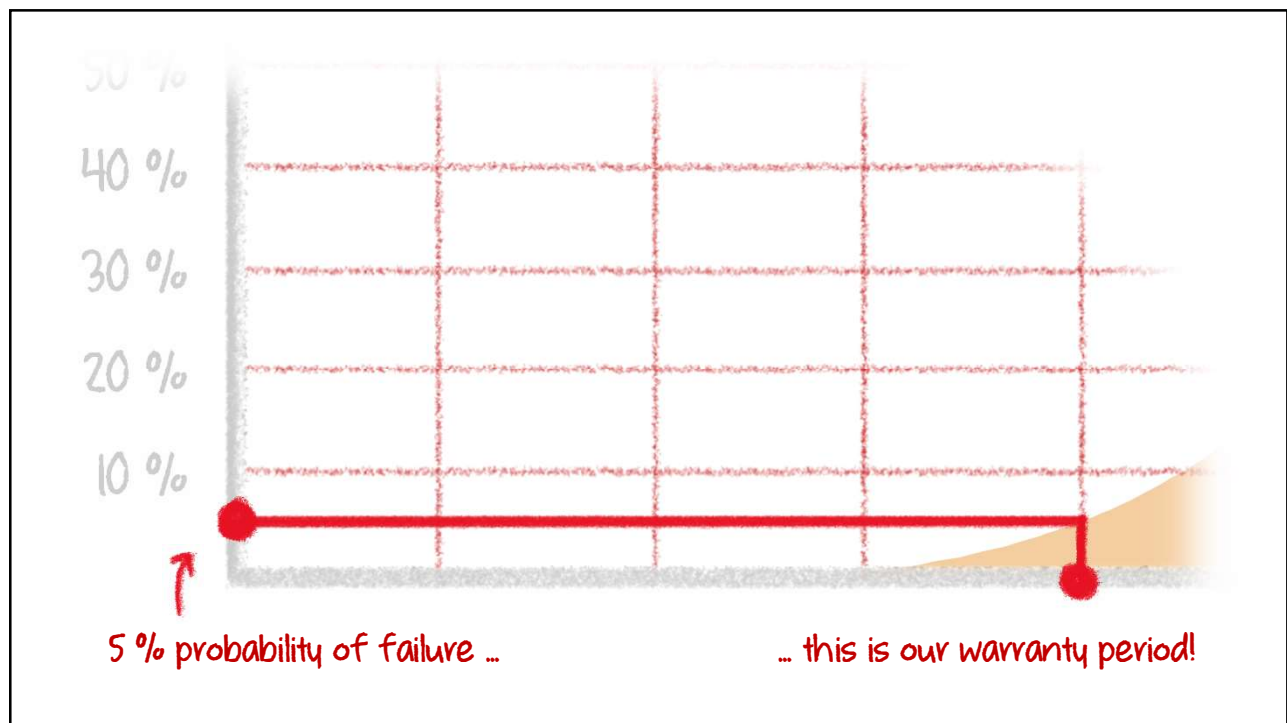
21

... so how does this
help us?

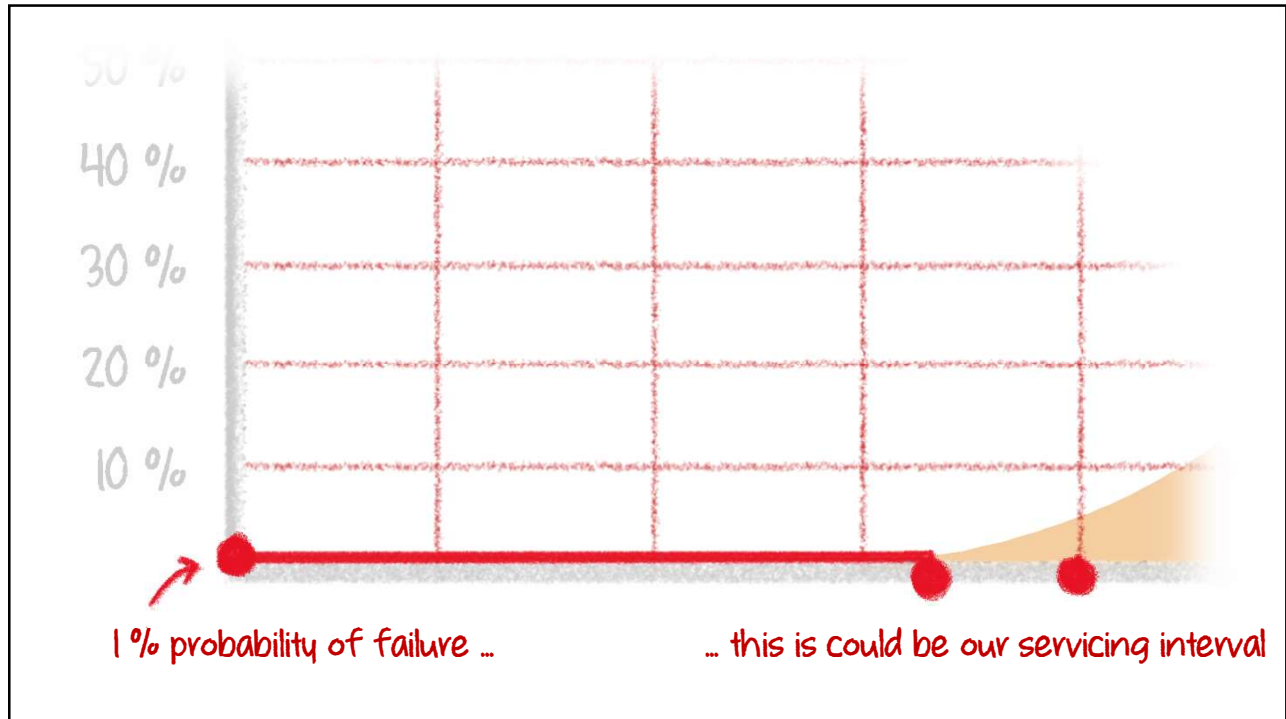
22



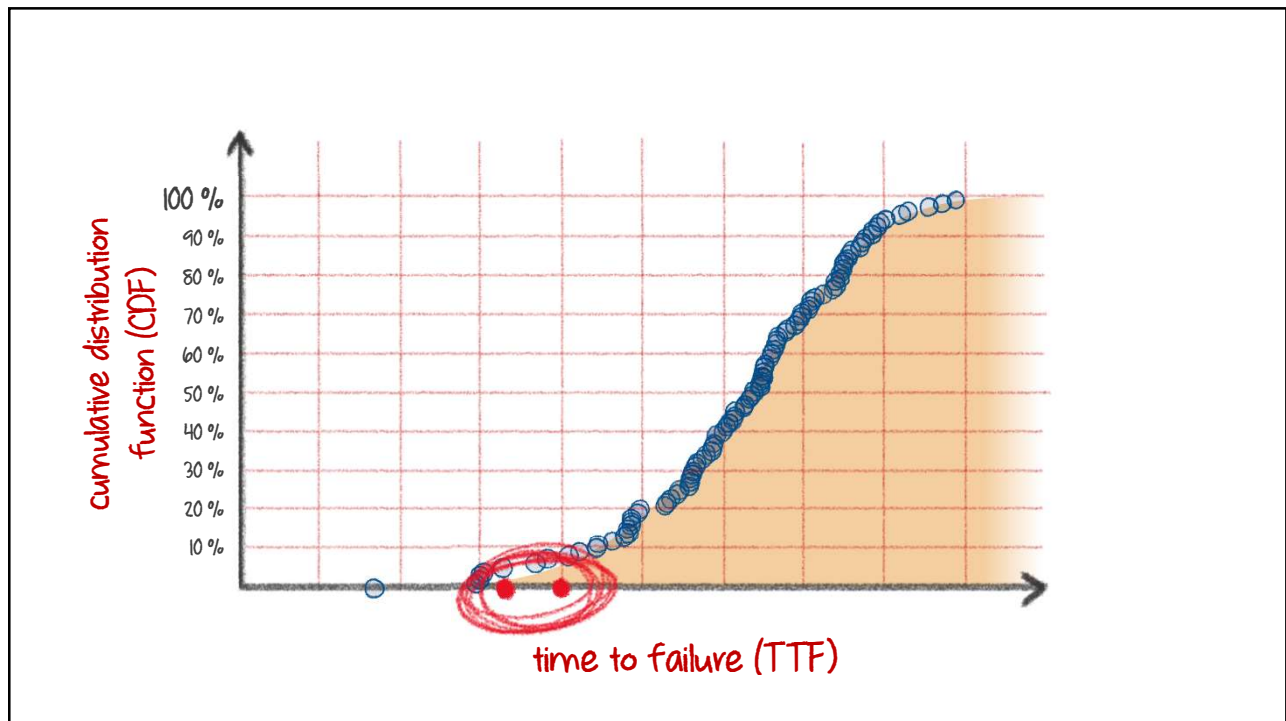
23



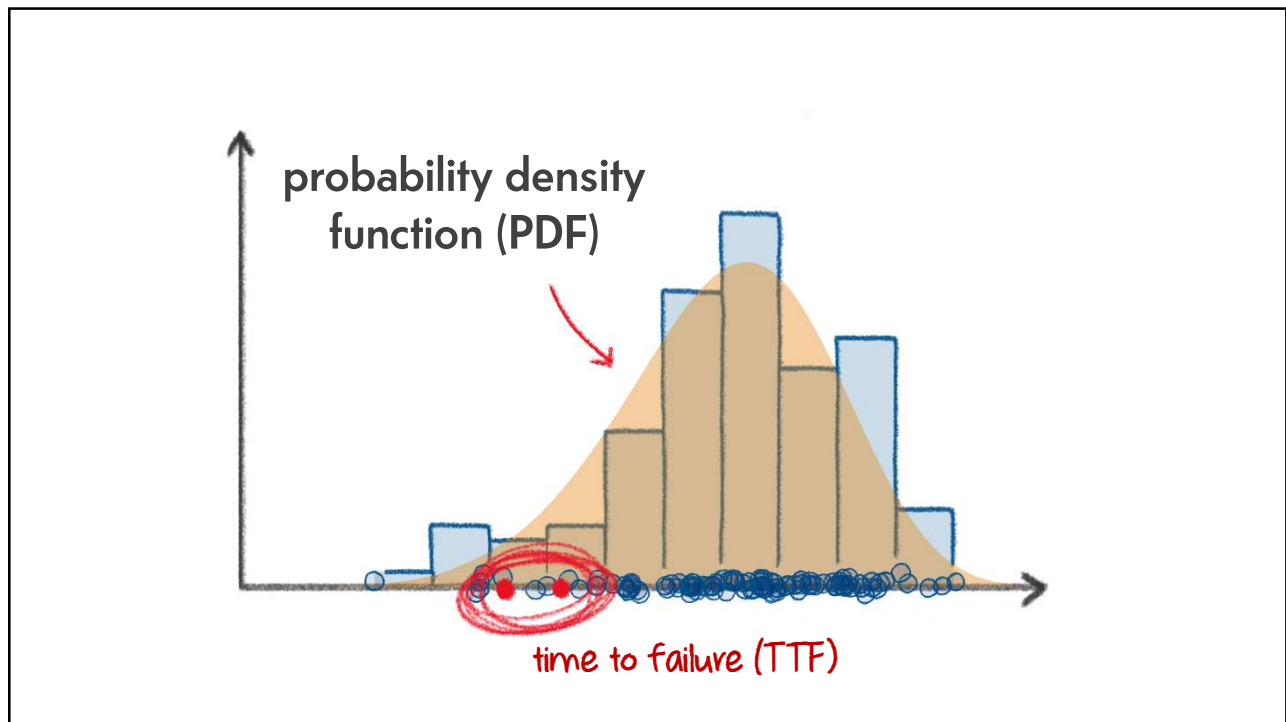
24



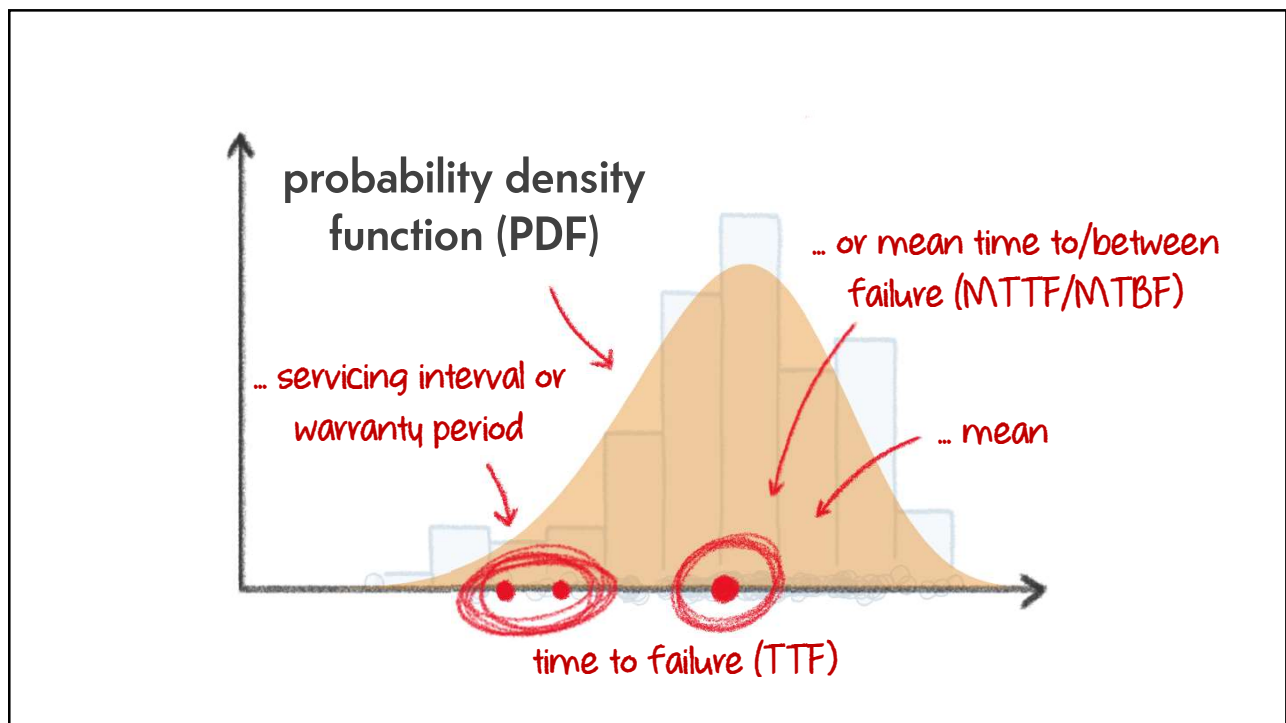
25



26



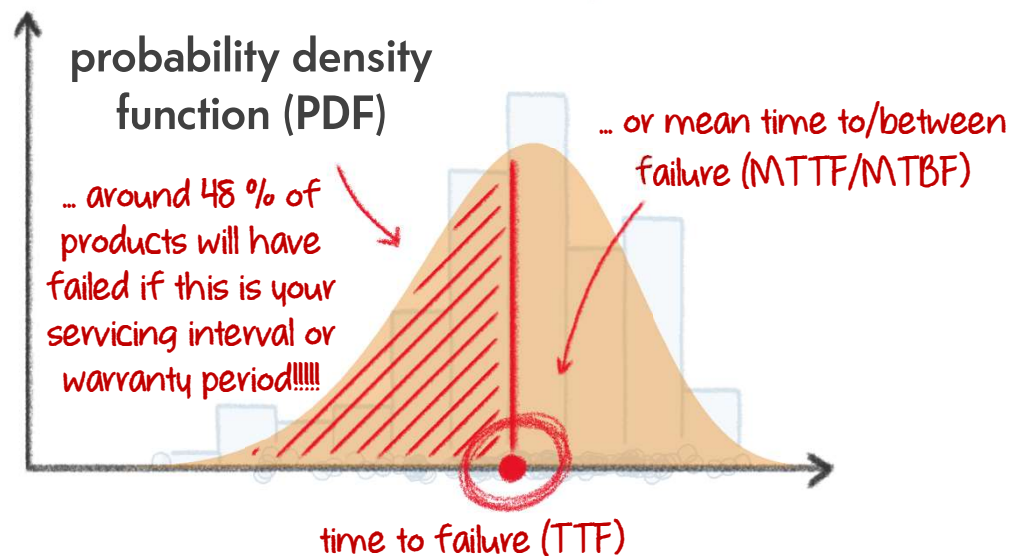
27



28

... what happens if we
make the servicing interval
or the warranty period
equal to the MTTF?

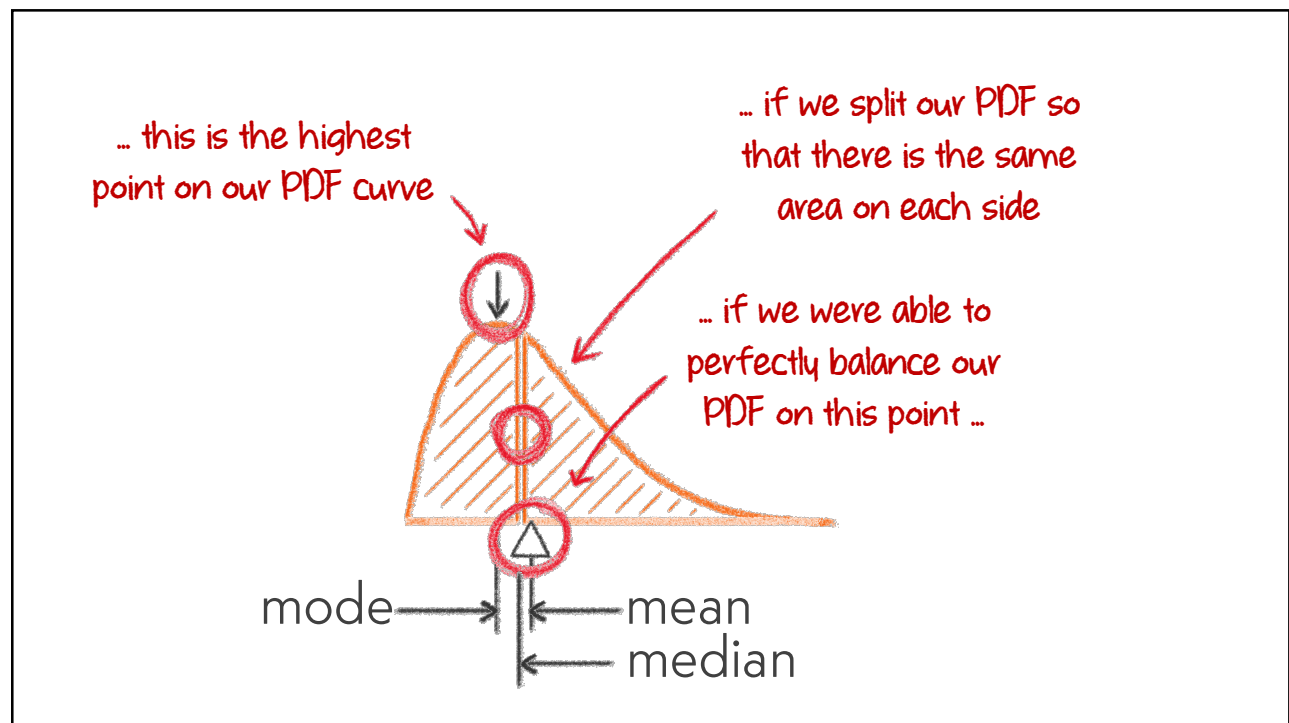
29



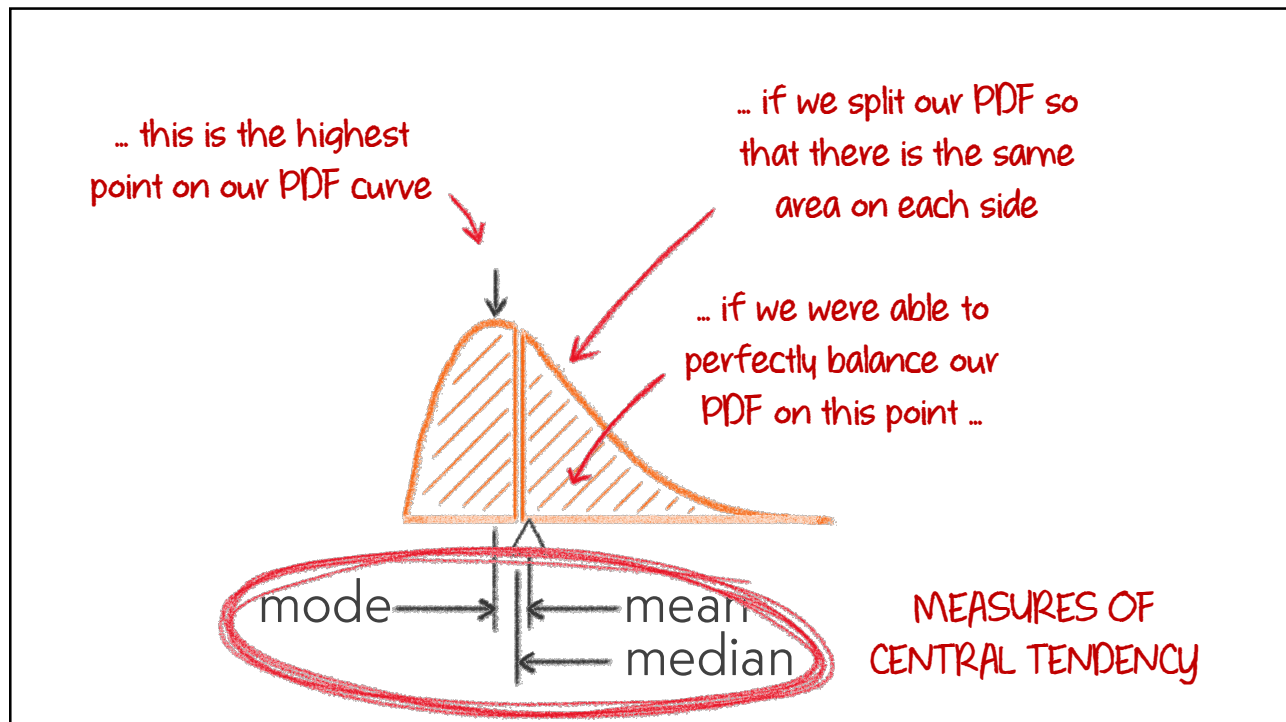
30

... so what is
the mean?

31



32



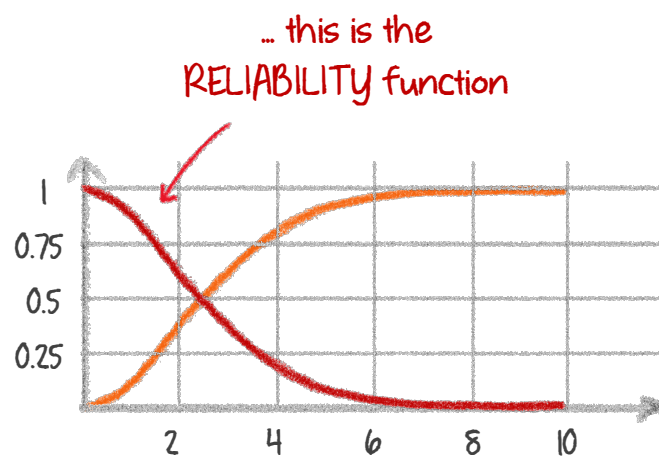
33

the **mean time to failure** helps us understand how many failures we *expect* to see in a year

34

... so what is
left?

35



36

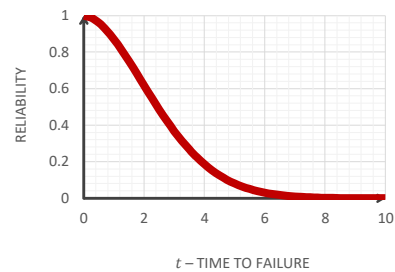
... anything
else?

37

probability density
function (PDF)



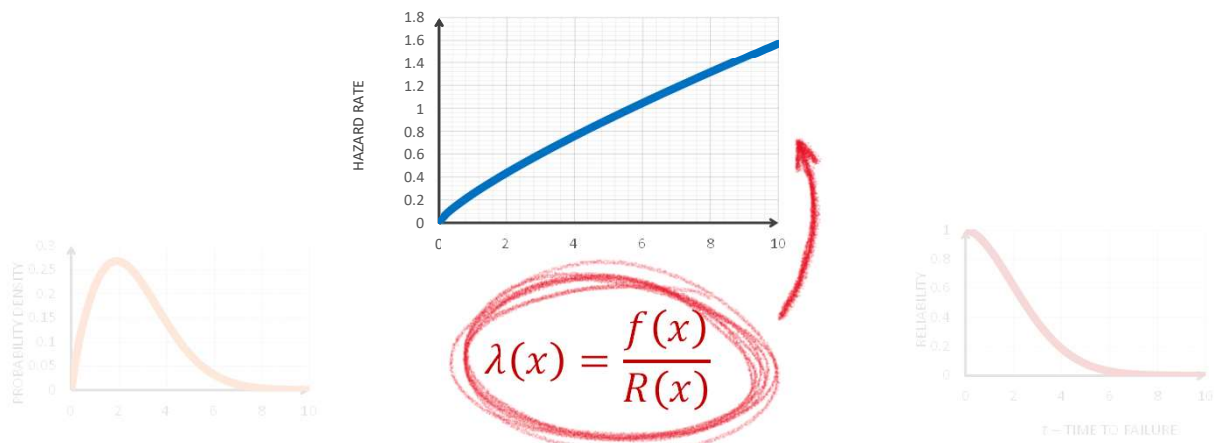
reliability
function



38

Hazard Rate

... the rate is the rate at which a functioning system fails with respect to usage

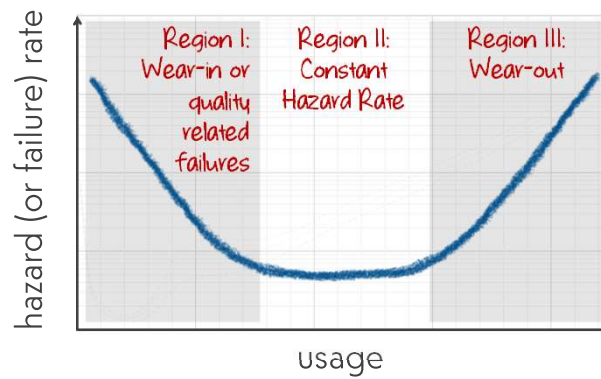


39

... and the most famous hazard rate curve of all is the bathtub curve

40

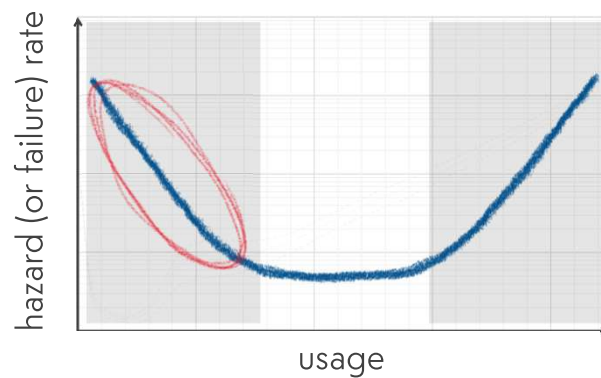
bathtub curve



41

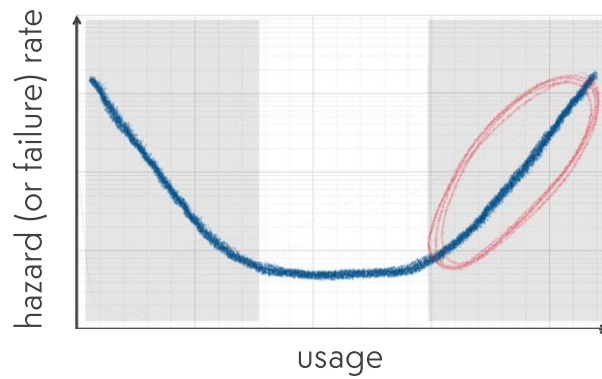
bathtub curve

- (1) manufacturing defects are removed,
or
(2) repair makes the system 'better than new/old'



42

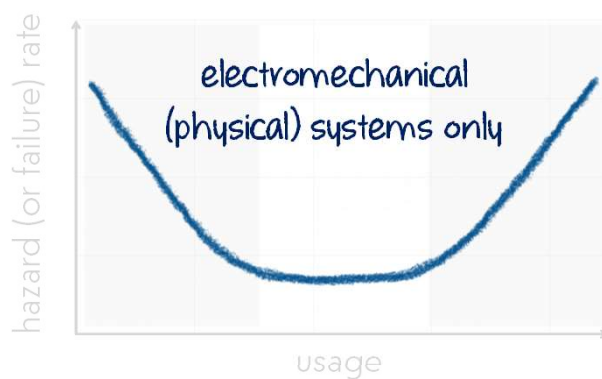
bathtub curve



... wear out applies to any failure mechanism that involves the accumulation of damage (or degradation more broadly)

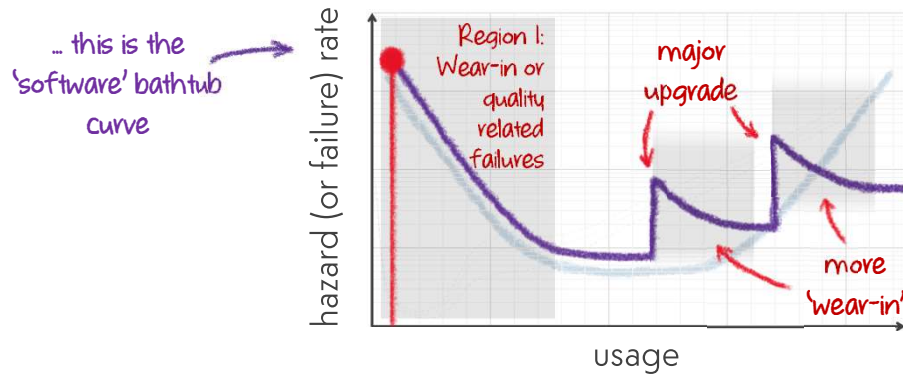
43

bathtub curve



44

bathtub curve

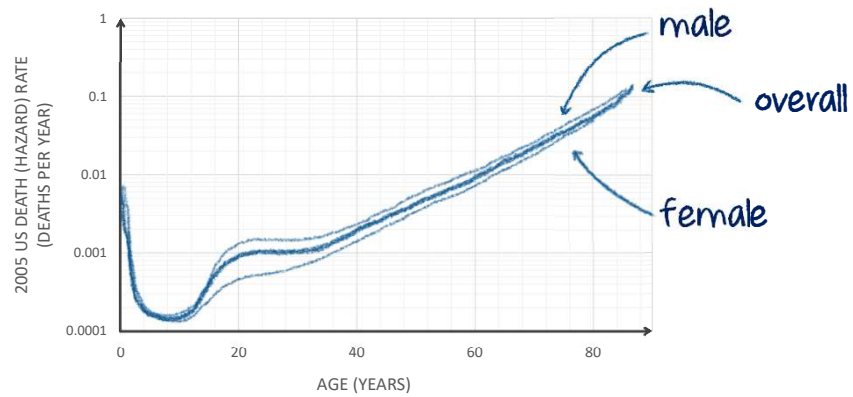


45

... not all bathtub curves look like a bathtub

46

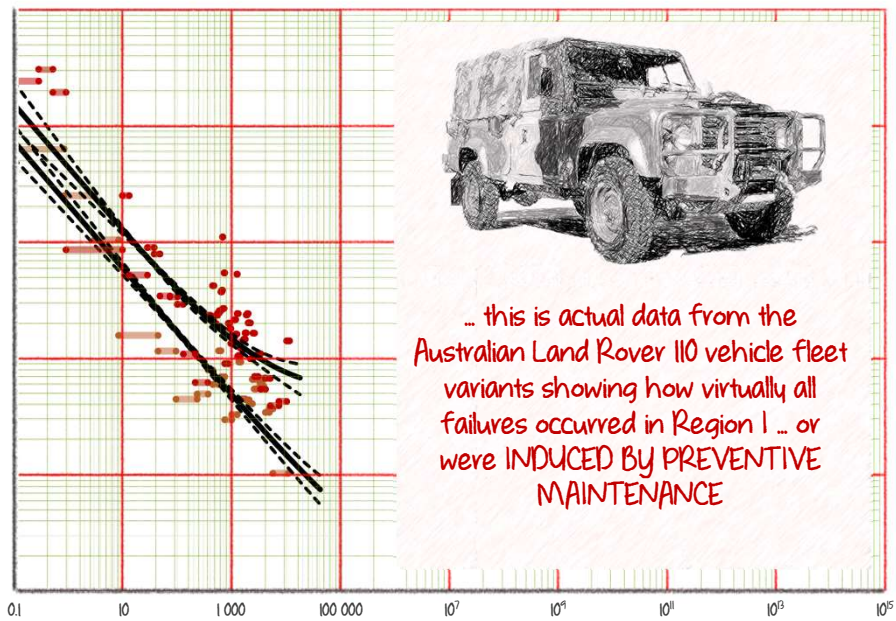
this is a
bathtub
curve for
human
beings
(2005 - USA)



Kung H-C, Hoyert D.L., Xu J., and Murphy, S.L., Deaths: Final Data for 2005, National Vital Statistics Reports, Volume 56, Number 10, April 24, 2008

47

HAZARD RATE



48

... so by doing less
preventive maintenance
(PM) we improved
reliability by 23 %.

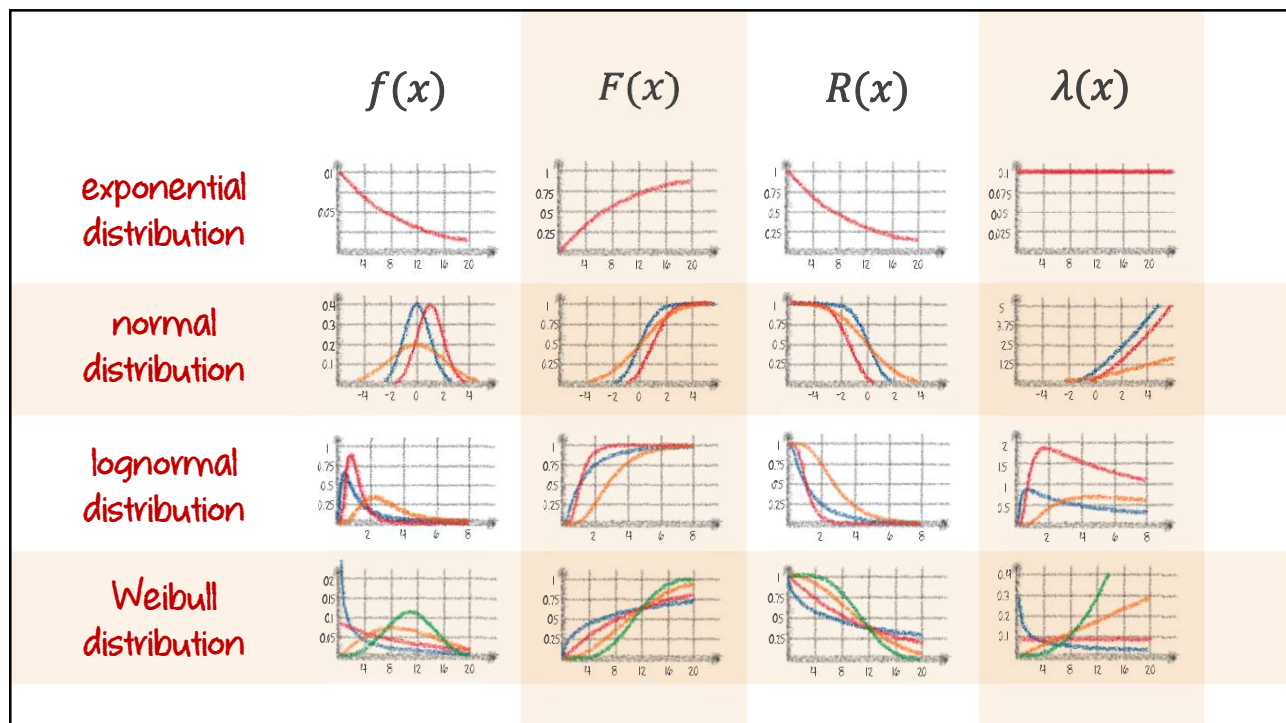
49

... the next
step?

50

... knowing which
one to use.

51



52



53