```r
# ex1
# X_1,...,X_20 ~ N(mu,2)
x=c(76, 75, 77, 74, 73, 77, 72, 74, 74, 73, 76, 74, 77, 73, 75, 75, 78, 72, 72, 77)

x=x-1
n=length(x)
# sigma connu
(p1 = 2*(1-pnorm(abs(mean(x)-75)*sqrt(5))))
(p2 = pnorm((mean(x)-75)*sqrt(5)))
# l'ecart-type de la statistique est 2/sqrt(n)
q=qnorm(0.975,0,1); w1=75-q*2/sqrt(n); w2=75+q*2/sqrt(n);
mean(x)<w1 | mean(x)>w2

# sigma inconnu
sd=sd(x)
(p1 = 2*(1-pt(abs(mean(x)-75)*sqrt(n)/sd,n-1)))
(p2 = pt((mean(x)-75)*sqrt(n)/sd,n-1))
# dans ce cas mean(x) centre reduit suit une loi de student a n-1 degre de liberte
sd=sqrt(var(x)); q=qt(0.975,n-1); w1=75-q*sd/sqrt(n); w2=75+q*sd/sqrt(n);
mean(x)<w1 | mean(x)>w2
# fonction t.test()
t.test(x); t.test(x, mu=75); t.test(x, mu=75,alternative = "less");
t.test(x,mu=75,conf.level=0.5)

# ex2
T=c(0,1,2,3,4,5,6,7,8,9,10)
Y=c(2,3,4,5,6,8,10,13,16,22,28)

# modèle linéaire
reg1=lm(Y~T)
summary(reg1)
par(mfrow = c(2,2))
plot(reg1,which=1)
plot(reg1,which=2)
plot(reg1,which=3)
plot(reg1,which=4)

# modèle exponentiel
lnY=log(Y)
reg2=lm(lnY~T)
summary(reg2)
par(mfrow = c(2,2))
plot(reg2,which=1)
plot(reg2,which=2)
plot(reg2,which=3)
plot(reg2,which=4)

# pseudo-R2
Y2=exp(reg2$fitted.values)
pR2=1-sum((Y-Y2)^2)/sum((Y-mean(Y))^2)
pR2

# test unilatéral
# beta>1
n=length(T)
beta1=reg1$coefficients[2]
sb1=0.2816
t1=(beta1-2)/sb1
p=1-pt(t1,n-2)
p

# beta>0.2
beta2=reg2$coefficients[2]
sb2=0.00514
t2=(beta2-0.2)/sb2
p=1-pt(t2,n-2)
p

# beta<3
```

```r
t1=(beta1-3)/sb1
ta=qt(0.05,n-2)
t1<ta

p=pt(t1,n-2)
p

# calcul des prédiction
mu=reg2$coefficients[1]
beta=reg2$coefficients[2]
x=25
y=exp(mu+beta*x)
y

# fonction predict()
newdata=data.frame(T=25)
y=predict(reg2,newdata)
y=exp(y)
y
# intervalles de confiance
s2=av2$Mean[2]
s2y=s2*(1+1/n+(25-mean(T))^2/((n-1)*var(T)))
yp=mu+beta*x
ta=qt(0.975,n-2)
ic1=yp-ta*sqrt(s2y)
ic2=yp+ta*sqrt(s2y)
ic1
ic2
exp(ic1)
exp(ic2)

p.int=predict(reg2,newdata,interval="prediction")
p.int

# test de normalité
shapiro.test(residuals(reg1))
shapiro.test(residuals(reg2))

Box.test (residuals(reg1), lag = 1, type = "Ljung")
Box.test (residuals(reg2), lag = 1, type = "Ljung")

x <- rnorm (100)
Box.test (x, lag = 1)
Box.test (x, lag = 5, type = "Ljung")
```