1. Solve this problem using both linear interpolation and linear regression.

```r
# load the required packages and provide the session information
install.load::load_package("data.table", "ggpubr", "iemisc")
# load needed packages using the load_package function from the install.load
# package (it is assumed that you have already installed these packages)

library("stats")

import::from(pracma, interp1)
# import interp1 from the pracma package

Time <- c(10, 15, 20, 25, 40, 50, 55, 60, 75) ## minutes

Tensile_Strength <- c(5, 20, 18, 40, 33, 54, 70, 60, 78) ## units

data <- data.table(Time = Time, Tensile_Strenth = Tensile_Strength)

## Plot the data

ggscatter(data, x = "Time", y = "Tensile_Strenth", add = "reg.line") + stat_regline_equation(aes(label = paste(., ., sep = "\n")), label.x.npc = "center")
```
## linear model (linear regression)

```r
lm.p <- lm(Tensile_Strength ~ Time) ## linear model

coeff(lm.p) ## coefficients of linear model

## (Intercept) Time
## 0.8179 1.0589

lm.p

## Call:
## lm(formula = Tensile_Strength ~ Time)
## Coefficients:
## (Intercept) Time
## 0.8179 1.0590
```

```r
summary(lm.p) ## summary of linear model

## Call:
## lm(formula = Tensile_Strength ~ Time)
## Residuals:
## Min 1Q Median 3Q Max
```
The difference between the linear interpolated value (true value) and the value obtained through linear regression (model value) is 6.0161435%.

2. Problem 33
3. Problem 38

4. Problem 39

5. Problem 44

6. Problem 46

7. Problem 47

8. Problem 49

9. Problem 56

10. Problem 59

11. Problem 60

The manual solutions follow.
Frame Analysis

Problem 33 Solution:

This is a statically determinate structure. We have four unknowns \((H_A, V_A, H_C, V_C)\), so that we need four equilibrium equations to solve this problem.

Check equilibrium of horizontal & vertical forces in the system (ton & ft):

\[
\begin{align*}
\sum F_x &= 0 & \sum F_y &= 0 \\
H_A &= H_C \quad \text{(1)} & V_A + V_C &= 2 \quad \text{(2)}
\end{align*}
\]

Check equilibrium of moment at joint A in the system (ton & ft):

\[
\sum M_A = 0 \\
2 \times 3 - H_C \times 2 - V_C \times 12 = 0 \\
H_C + 6V_C = 3 \quad \text{(3)}
\]
Check the moment at pin B for the right part (ton & ft):

\[ M_B = 0 \]
\[ H_c \times 4 - V_c \times 6 = 0 \]
\[ H_c = 1.5V_c \ldots \text{(4)} \]

Substituting equation (4) to equation (3):

\[ H_c + 6V_c = 3 \ldots \text{(3)} \]
\[ 1.5V_c + 6V_c = 3 \]
\[ V_c = 0.4 \text{ ton (↑)} \]

Therefore, the horizontal reaction at support C can be calculated using equation (4):

\[ H_c = 1.5V_c \ldots \text{(4)} \]
\[ H_c = 1.5 \times 0.4 = 0.6 \text{ ton (←)} \]

(Answer B)
Centroidal Polar Moment of Inertia

Problem 38 Solution:

\[ J = I_{xx} + I_{yy} = 2140 + 838 = 2978 \text{ in}^4 \]

(Answer D)
Kinematic Function

Problem 39 Solution:

Velocity is defined in terms of time, so that distance can be written as follows:

\[ s(t) = \int v(t) \, dt \]

\[ = \int_{2}^{6} (5t + 3) \, dt \]

\[ = \frac{5}{2} t^2 + 3t \bigg|_{2}^{6} \]

\[ = 92 \text{ m} \]

(Answer D)
Work & Energy

Problem 44 Solution:

The inclined plane is frictionless, so there is no energy loss in the system. Use the conservation of energy to solve this.

\[ E_i = E_f \]

\[ mgh = \frac{1}{2} k\Delta^2 \]

\[ 2 \times 9.8 \times 5 = \frac{1}{2} \times 500 \times \Delta^2 \]

\[ \Delta = 0.62 \text{ m} \]

(Answer B)
Shear Force Diagram

Problem 46 Solution:

Before drawing the shear force diagram, first we need to find the support reactions. For this case, the applied concentrated loading is in the mid-span, so that the reaction at both supports is half of the applied loading = 2.5 kips (upward each).

Shear Force Diagram (unit: kips)

(Answer A)
Bending Moment Diagram

Problem 47 Solution:

For this case, the bending moment increases linearly until the maximum moment is located when the shear force diagram is zero.

![Bending Moment Diagram (unit: kips-ft)](Answer A)
Strain (Elastic Deformation)

Problem 49 Solution:

\[
\Delta = \frac{PL}{EA} = \frac{80 \text{ lb} \times \left(25 \text{ ft} \times 12 \text{ in/ft}\right)}{(10900 \times 10^3 \text{ psi}) \times \left(\frac{1}{4} \pi \times (0.25 \text{ in})^2\right)} = 0.045 \text{ in}
\]

\[
\varepsilon = \frac{\Delta}{L} = \frac{0.045 \text{ in}}{25 \text{ ft} \times 12 \text{ in/ft}} = 1.5 \times 10^{-4}
\]

(Answer C)
Standard Testing Methods for Material

Problem 56 Solution:

ASTM contains:

- C136-06 covers the standard test method for sieve analysis for fine and coarse aggregates.
- C127-12 covers the standard test method for density, relative density (specific gravity), and absorption of coarse aggregates.
- C128-12 covers the standard test method for density, relative density (specific gravity), and absorption of fine aggregates.

(Answer D)
Concrete Admixtures

Problem 59 Solution:

Accelerator is used to shorten the setting time in concrete.

Retarder is used to extend the setting time of cement paste in concrete.

Plasticizer / water reducer is used to increase the workability of concrete, allowing the concrete be placed more easily.

Air entraining agent is used to provide space for the water to expand upon freezing.

(Answer C)
Fluid Properties

Problem 60 Solution:

Kinematic viscosity ($\nu$) is defined as the ratio of absolute viscosity ($\mu$) to mass density ($\rho$), written as follows:

$$\nu = \frac{\mu}{\rho}$$

(Answer D)