46 Practice Exam #1

46.1 A fan supplies air through a $12in$ by $18in$ rectangular sheet metal duct with $1in$ fiberglass insulation. The duct run is $15ft$ long. Local octave band measurements of the sound power level for the fan are $125Hz$, $95dB$; $250Hz$, $94dB$; $500Hz$, $92dB$; $1000Hz$, $90dB$; $2000Hz$, $85dB$; $4000Hz$, $69dB$. What is the expected sound power level for the $1000Hz$ octave band at the end of the duct run?

A. $35dB$

B. $52dB$

C. $69dB$

D. $86dB$

Refer to the table Insertion Loss for Rectangular Sheet Metal Ducts with 1 in. Fiberglass Lining. Look up dimensions $12in$ by $18in$ and note the insertion loss for the $1000Hz$ octave band is $3.7\frac{dB}{ft}$. Multiply the loss per foot times the length of the duct to obtain the total dB reduction.

$$\left(3.7\frac{dB}{ft}\right)(15ft) = 55.5dB$$

Subtract the dB reduction from the measured sound power level for the $1000Hz$ octave band to obtain the final sound power level with the indulated duct inserted.

$$90dB - 55.5dB = 34.5dB$$

Answer A

46.2 A normal shock wave in air has a Mach number of 3. The pressure upstream is $1atm$, what is the pressure downsteam?

A. 2 psi

B. 10 psi

C. 60 psi

D. 150 psi

There are two possible approaches for this problem, the first using the Normal Shock Relationships table and the second using equations relating downstream flow conditions to upstream flow conditions for a normal shock wave. In both cases, the subscript 1 is used to represent the upstream conditions and the subscript 2 is used to represent the downstream conditions.

Using the table, for $M_1 = 3$, find the corresponding pressure ratio.

$$\frac{P_2}{P_1} = 10.3333$$

Since the upstream pressure is known, substitute for P_1 and convert from atm to psi.

$$P_2 = 10.3333\,(P_1) = 10.3333\,(1atm)\left(\frac{14.7psi}{atm}\right) = 152psi$$

Alternatively, since the table values have been generated for convenience, it is also valid to use the underlying formulas to solve for the pressure ratio. The ratio of specific heats, k, is assumed to be 1.4.

$$\frac{P_2}{P_1} = \left(\frac{1}{k+1}\right)\left[2kM_1^2 - (k-1)\right]$$

$$\frac{P_2}{P_1} = \left(\frac{1}{1.4+1}\right)\left[2\,(1.4)\,(3)^{\,2} - (1.4-1)\right] = 10.3333$$

The rest of the solution follows from the first approach.

Answer D

46.3 A company purchases a factory for $1M with a salvage value of $300K in 15 years. Operations and maintenance costs are $40K/year. At an interest rate of 8%, what is the equivalent uniform annual cost of the factory over the next 15 years?

A. $70K

B. $90K

C. $150K

D. $170K

Draw a cash flow diagram or make a list of cash flows. Since the problem is asking for EUAC, this solution treats costs as positive.

For year 0 there is a payment for the original purchase of $1M.

For years 1 through 15 there is an annualized payment for operation and maintenance of $40K per year.

For year 15 there is a positive cash flow of $300K for the salvage value which partially offsets the costs.

Since the O&M cost in years 1 through 15 is already annualized, there is no need for further manipulation.

The initial cost and the salvage value need to be transformed into annualized cash flows and added to the O&M. Use the Factor Table for 8% to look up the required cash flow factors. Solve for the EUAC.

$$EUAC = \$40,000 + \$1,000,000\,(A/P, 8\%, 15) - \$300,000\,(A/F, 8\%, 15)$$

$$EUAC = \$40,000 + \$116,800 - 11,040 = \$145,760$$

Answer C