

$$v_3 = \frac{(5.047in)^2 \left(2\frac{ft}{s}\right) + (3.068in)^2 \left(5\frac{ft}{s}\right)}{(6.065in)^2} = 2.66\frac{ft}{s}$$

**Answer C**

**46.15** A  $100lb_m$  mass rests on 4 springs, each with a spring constant of  $15\frac{lb_f}{in}$ . The mass is initially displaced from its equilibrium position, then released. What is the resulting period of oscillation?

- A.  $0.03s$
- B.  $0.1s$
- C.  $0.4s$
- D.  $2.3s$

Refer to the section on **Free Vibration**. Recognize that the spring constant for springs in parallel add linearly, therefore the total spring constant for the system can be determined as follows.

$$k_{total} = 4(k_{spring}) = (4) \left(15\frac{lb_f}{in}\right) = 60\frac{lb_f}{in}$$

Find the natural frequency, which is a function of the total spring constant and the mass. The relevant formula may be found by searching **undamped natural circular frequency**. Note  $g_c$  must be included to change  $lb_m$  to  $lb_f$  for consistency of units. This is not given in the reference handbook and must be inferred by the inconsistency of the units if not addressed. Also note the appearance of radians in the result for this application. Be assured this is valid and expected with analysis of vibrating systems.

$$\omega_n = \sqrt{\frac{kg_c}{m}} = \sqrt{\frac{\left(60\frac{lb_f}{in}\right) \left(32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}\right) \left(\frac{12in}{ft}\right)}{100lb_m}} = 15.2\frac{rad}{s}$$

Find the period. The relevant formula may be found by searching **undamped natural period of vibration**.

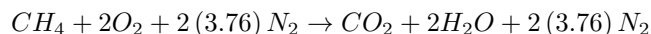
$$\tau_n = \frac{2\pi}{\omega_n} = \frac{2\pi rad}{15.2\frac{rad}{s}} = 0.4s$$

**Answer C**

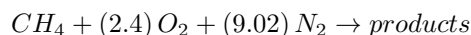
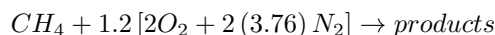
**46.16 Methane is burned with 20% excess air. What is the air-to-fuel ratio?**

- A.  $14 \frac{lb}{lb}$
- B.  $17 \frac{lb}{lb}$
- C.  $21 \frac{lb}{lb}$
- D.  $24 \frac{lb}{lb}$

Look up the table **Combustion Reactions of Common Fuel Constituents** and find the combustion reaction for methane burned stoichiometrically in air. Include 3.76 nitrogen molecules for every 1 oxygen molecule since nitrogen has been omitted in the table. Nitrogen does not participate in the reaction; however, it does contribute mass to the air and thus impacts the air-to-fuel ratio.



Add 20% excess air. Air-to-fuel ratio applies only to the reactants, so it is not necessary to balance the reaction and write out the product side.



Calculate the air-to-fuel ratio by multiplying the number of moles of each constituent times the atomic weight and dividing the air mass by the fuel mass. Use the **Periodic Table** to look up atomic weights as needed.

$$\frac{m_{air}}{m_{fuel}} = \frac{n_{O_2} M_{O_2} + n_{N_2} M_{N_2}}{n_{CH_4} M_{CH_4}} = \frac{(2.4)(32) + (9.02)(28)}{(1)(16)} = 20.6 \frac{lb}{lb}$$

Alternatively, in the **Combustion Reactions** table, notice the heading for **Stoichiometric Oxygen and Air Requirements**. The amount of air required to burn methane stoichiometrically is given as  $17.24 \frac{lb}{lb}$ . Increase this value by 20% to account for excess air.

$$(1.2) \left( 17.24 \frac{lb}{lb} \right) = 20.7 \frac{lb}{lb}$$

**Answer C**