Worked Solutions for ENGAA Papers by Topic

Section 2

Topic: Forces

Section 2 Topic	Number of S2 Questions 2016 - 2020
Algebra	2
Electricity	18
Energy	3
Forces	7
Geometry	4
Kinematics	13
Materials	4
Mechanics	21
Waves	14

ENGAA S2 2020 - Question 1

1 Spring P has spring constant $1.0\,\text{N}\,\text{cm}^{-1}$ and spring Q has spring constant $3.0\,\text{N}\,\text{cm}^{-1}$.

The two springs are connected in series.

The springs are stretched by 6.0 cm in total.

What is the extension of spring P?

(The springs have negligible mass and obey Hooke's law.)

A 1.5 cm

B 2.0 cm

C 3.0 cm

D 4.0 cm

E 4.5 cm

ENGAA S2 2020 - Question 1 - Worked Solution

$$k_P : k = 1 : 3$$

$$x_P : x_Q = 3 : 1$$

$$x_P = \frac{6cm}{4} \times 3 = 4.5cm$$

Answer is E

ENGAA S2 2020 - Question 4

4 A solid cube with sides of length 20 cm is made from material with density 2000 kg m^{-3}. The cube is suspended, in equilibrium, from an initially unstretched spring, and this results in the spring gaining strain energy of 3.2 J.

What is the spring constant of the spring?

(gravitational field strength = 10 N kg^{-1}; the spring obeys Hooke's law)

A 40 N m^{-1}

B 80 N m^{-1}

C 400 N m^{-1}

D 800 N m^{-1}

E 4000 N m^{-1}

F 8000 N m^{-1}

ENGAA S2 2020 - Question 4 - Worked Solution

$$m = \rho V = 16kg$$

$$E_s = \frac{1}{2}$$

$$= \frac{F^2}{2k}$$

$$k = \frac{(mg)^2}{2E_s} = 400 \text{ N m}^{-1}$$

Answer is E

ENGAA S2 2020 - Question 9

9 An apple of mass m_a is placed on a uniform metre rule with the centre of gravity of the apple at the 10 cm mark. The rule is balanced on a pivot placed at the 35 cm mark.

The apple is replaced with an orange of mass m_o. The rule now balances with the pivot at the 40 cm mark.

What is the ratio $\frac{m_a}{m_o}$?

A $\frac{5}{9}$

B $\frac{4}{5}$

C $\frac{5}{6}$

D $\frac{6}{5}$

E $\frac{5}{4}$

F $\frac{9}{5}$

ENGAA S2 2020 - Question 9 - Worked Solution

Torques:

$$m_a \,.\, 25 = m_r \,.\, 15$$

$$m_o \,.\, 30 = m_r \,.\, 10$$

$$\frac{m_a}{m_o} \,.\, \frac{25}{30} = \frac{15}{10}$$

$$\frac{m_a}{m_o} = \frac{9}{5}$$

Answer is F

ENGAA S2 2020 - Question 14

14 An object of mass M experiences a resultant force of magnitude F. The force acts in a single horizontal direction with a magnitude that varies with time t according to

$$F = X + Y\sqrt{t}$$

where X and Y are constants.

The object is at rest at $t = 0$.

What is the magnitude of the momentum of the object at time $t = T$?

A $T\left(X + \frac{2}{3}Y\sqrt{T}\right)$

B $T\left(X + Y\sqrt{T}\right)$

C $\frac{T}{M}\left(X + \frac{2}{3}Y\sqrt{T}\right)$

D $\frac{T}{M}\left(X + Y\sqrt{T}\right)$

E $\frac{Y}{2\sqrt{T}}$

F $\frac{Y}{2M\sqrt{T}}$

ENGAA S2 2020 - Question 14 - Worked Solution

$$F = \frac{dP}{dt}$$

$$thus \quad P = \int F dt$$

$$P_T = \int_{t=0}^{t=T} \left(x + y\sqrt{t}\right) dt$$

$$t = 0$$

$$= \left| xt + \frac{2}{3} y t^{3/2} \right|_0^T$$

$$P_T = T\left(x + \frac{2}{3} y\sqrt{T}\right)$$

Answer is A

ENGAA S2 2019 - Question 12

12 A light spring has unstretched length 0.40 m and spring constant $50\,\text{N m}^{-1}$.

The spring is stretched by a varying tension force that starts at a value of zero and increases at a constant rate of $0.20\,\text{N s}^{-1}$ up to a maximum value.

When the force reaches its maximum value, the strain energy of the spring is 0.25 J.

What is the average power used to stretch the spring?

(Assume that the spring obeys Hooke's law.)

A 0.010 W

B 0.020 W

C 0.040 W

D 0.080 W

E 1.0 W

F 2.0 W

G 4.0 W

H 8.0 W

ENGAA S2 2019 - Question 12 - Worked Solution

$$\frac{1}{2}Fx = 0.25$$

$$\frac{1}{2}kx^2 = 0.25 \rightarrow PE$$

$$\frac{1}{2}kx^2 = 25x^2$$

$$x = 10m$$

$$\frac{1}{2}F\,.\,10 = 0.25$$

$$\therefore F = 0.05N$$

$$Rate\ of\ increasing\ force: 0.2Ns^{-1}$$

$$\frac{0.05N}{0.2Ns^{-1}} = 25s$$

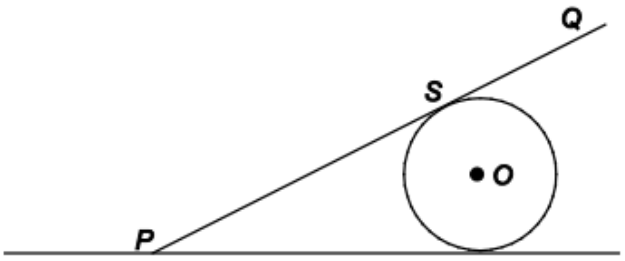
$$P = \frac{E}{t} = \frac{0.25J}{25s} = 0.01W$$

Answer is A

ENGAA Specimen S2 - Question 17

17 *PQ* is a thin, uniform rod of length 4 m and mass 5 kg.

[diagram not to scale]



A fixed, thin disc has radius 2 m and centre *O*.

P rests on a rough horizontal plane and *PQ* rests in equilibrium touching the disc at the point *S*.

The distance *PO* is 4 m.

The rod and the disc are in the same vertical plane, as in the diagram.

What is the normal contact force between the disc and the rod?

(gravitational field strength = g)

A $2.5g$

B $\frac{5\sqrt{3}g}{6}$

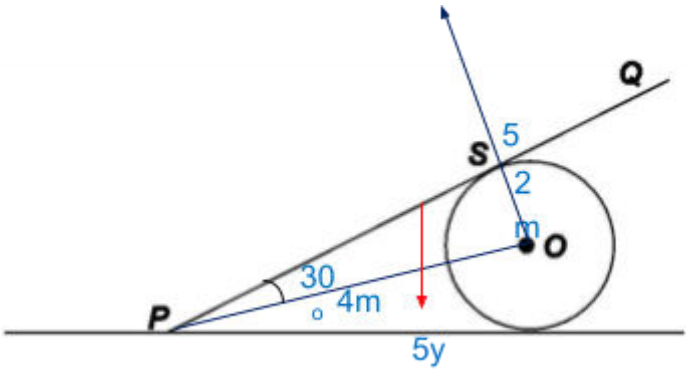
C $\frac{5\sqrt{3}g}{3}$

D $\frac{10\sqrt{3}g}{3}$

E $5g$

F $10g$

ENGAA Specimen S2 - Question 17 - Worked Solution



$$PS^2 + 2^2 = 4^2$$

$$PS = 2\sqrt{3}m$$

Taking moments about P:

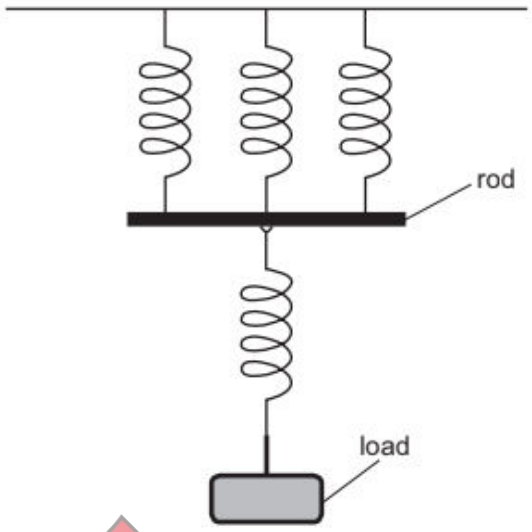
$$2\sqrt{3}N = 2\cos\cos 60° \times 5g = 5g$$

$$N = \frac{5g}{2\sqrt{3}}$$

Answer is B

ENGAA S2 2018 - Question 10

10 Four identical light springs are connected together using a light rod. A load of mass m is suspended from the system so that the rod is horizontal, as shown in the diagram.



The spring constant of each spring is k and all four springs obey Hooke's law throughout.

Which of the following expressions gives the elastic potential energy stored in the system?

(gravitational field strength = g)

A $\frac{(mg)^2}{6k}$

B $\frac{(mg)^2}{2k}$

C $\frac{5(mg)^2}{9k}$

D $\frac{2(mg)^2}{3k}$

E $\frac{(mg)^2}{k}$

F $\frac{2(mg)^2}{k}$

ENGAA S2 2018 - Question 10 - Worked Solution

For spring in parallel:

K +k +k = 3k

Total spring constant for the springs in series:

$$K_T = \left(\frac{1}{3k} + \frac{1}{k}\right)^{-1}$$

$$= \frac{3k}{4}$$

Equal forces:

$$mg = \frac{3k}{4}x$$

$$x = \frac{4mg}{3k}$$

$$E = \frac{1}{2}kx^2$$

$$= \frac{1}{2} \times \frac{3k}{4} \times \left(\frac{4mg}{3k}\right)^2$$

$$= \frac{2(mg)^2}{3k}$$

Answer is D.