

First Name: _____

Last Name: _____

1.07 - Worksheet - Review - Power, Work and Energy /28 marks

Note: This worksheet does not cover oscillatory motion.

Pt 1: Mechanical Energy _____ / 5 marks

Pt 2: Hooke's Law and Elastic Potential Energy _____ / 6 marks

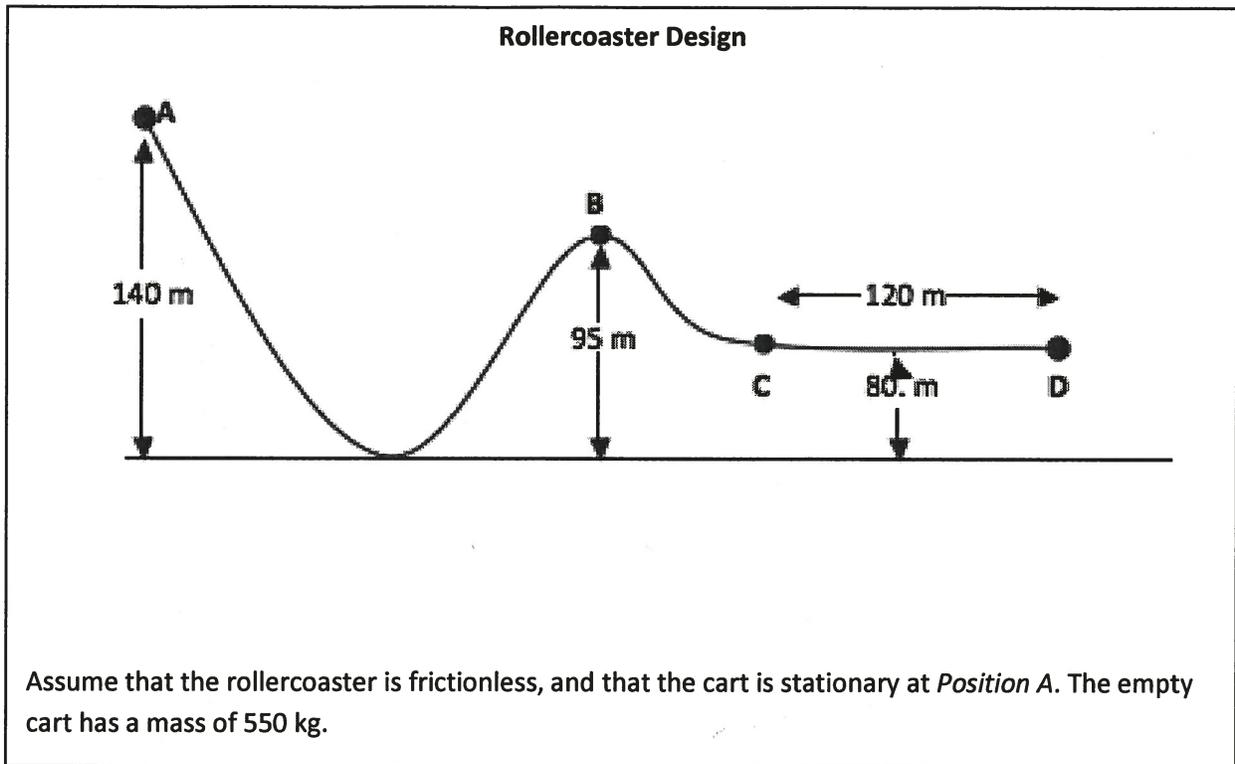
Pt 3: Graphical Representation of Hooke's Law _____ / 6 marks

Pt 4: Elastic Potential Energy and Conservation of Energy _____ / 4 marks

Pt 5: Work and Power _____ / 7 marks

Part 1 – Mechanical Energy

Use the following information to answer Q1:



Q1: How much potential energy does the cart have while at *Position A*?

- a. 1.37×10^3 N
- b. 1.37×10^3 J
- c. 7.55×10^5 N
- d. 7.55×10^5 J

$$E_p = mgh$$

$$= (550 \text{ kg})(9.81 \text{ m/s}^2)(140 \text{ m})$$

$$= 7.55 \times 10^5 \text{ J}$$

Q2: How fast is the cart travelling when it reaches *Position B*?

- a. 14.9 m/s
- b. 17.6 m/s
- c. 21.0 m/s
- d. 29.7 m/s

$$E_m = 7.55 \times 10^5 \text{ J}$$

$$E_p = mgh = 5.13 \times 10^5 \text{ J}$$

$$E_k = E_m - E_p = 2.43 \times 10^5 \text{ J}$$

$$E_k = \frac{1}{2}mv^2$$

$$2.43 \times 10^5 \text{ J} = \frac{1}{2}(550 \text{ kg})v^2$$

$$v^2 = 882.9$$

$$v = 29.7 \text{ m/s}$$

Q3: How long will it take the cart to get from *Position C* to *Position D*?

- a. 2.3 s
- b. 3.5 s
- c. 4.0 s
- d. 6.1 s

$$E_m = 7.55 \times 10^5 \text{ J}$$

$$E_p = mgh = (550)(9.81)(80) = 431,640 \text{ J}$$

$$E_k = E_m - E_p = 323,730 \text{ J}$$

$$E_k = \frac{1}{2}mv^2$$

$$323,730 \text{ J} = \frac{1}{2}(550 \text{ kg})v^2$$

$$v^2 = 1177.2$$

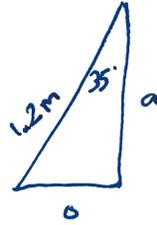
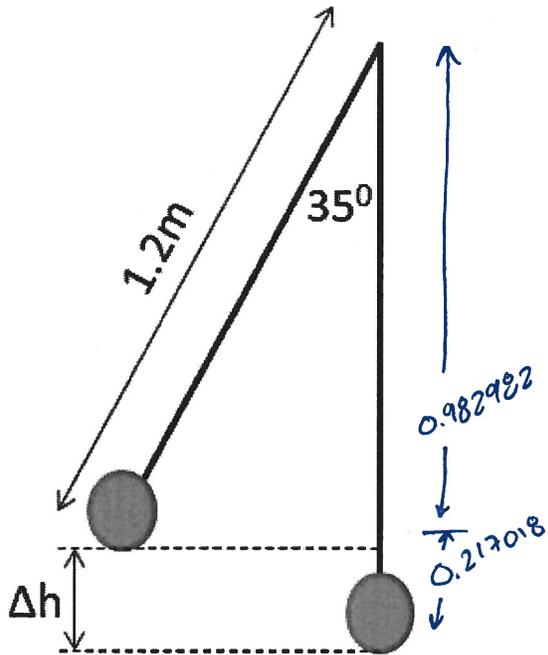
$$v = 34.3 \text{ m/s}$$

$$v = \frac{d}{t}$$

$$34.3 \text{ m/s} = \frac{120 \text{ m}}{t}$$

$$t = 3.5 \text{ s}$$

Q4: (Long Answer) A mass on a pendulum is raised 35° , as depicted below. How fast is it travelling when it reaches the very bottom of its arc? (2 marks)



$$\cos \theta = \frac{a}{h}$$

$$\cos 35^\circ = \frac{a}{1.2}$$

$$a = 0.982982\text{m}$$

$$E_p \rightarrow E_k$$

$$mgh = \frac{1}{2}mv^2$$

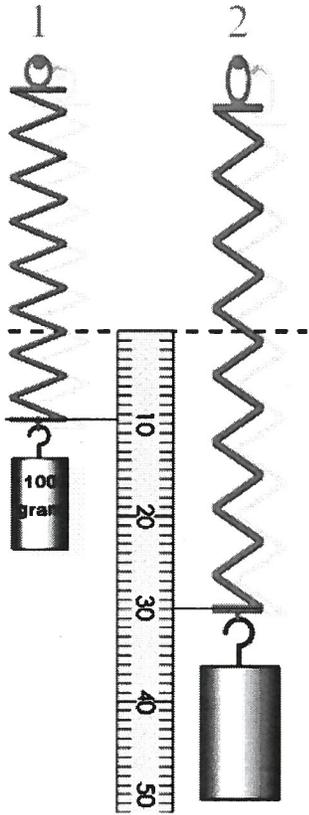
$$gh = \frac{1}{2}v^2$$

$$(9.81)(1.2 - 0.982982) = \frac{1}{2}v^2$$

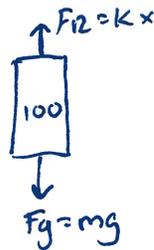
$$v = 2.07\text{ m/s}$$

Part 2 – Hooke's Law and Elastic Potential Energy

Q5: (Long Answer) What is the mass of the unknown mass below, in grams, if a 100g mass stretches the spring a distance of 9.5cm? (2 marks)



Part 1



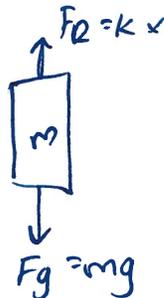
$$F_g = F_R$$

$$mg = kx$$

$$(0.1\text{kg})(9.81\text{ m/s}^2) = k(0.095\text{m})$$

$$k = 10.3263\text{ N/m}$$

Part 2



$$F_g = F_R$$

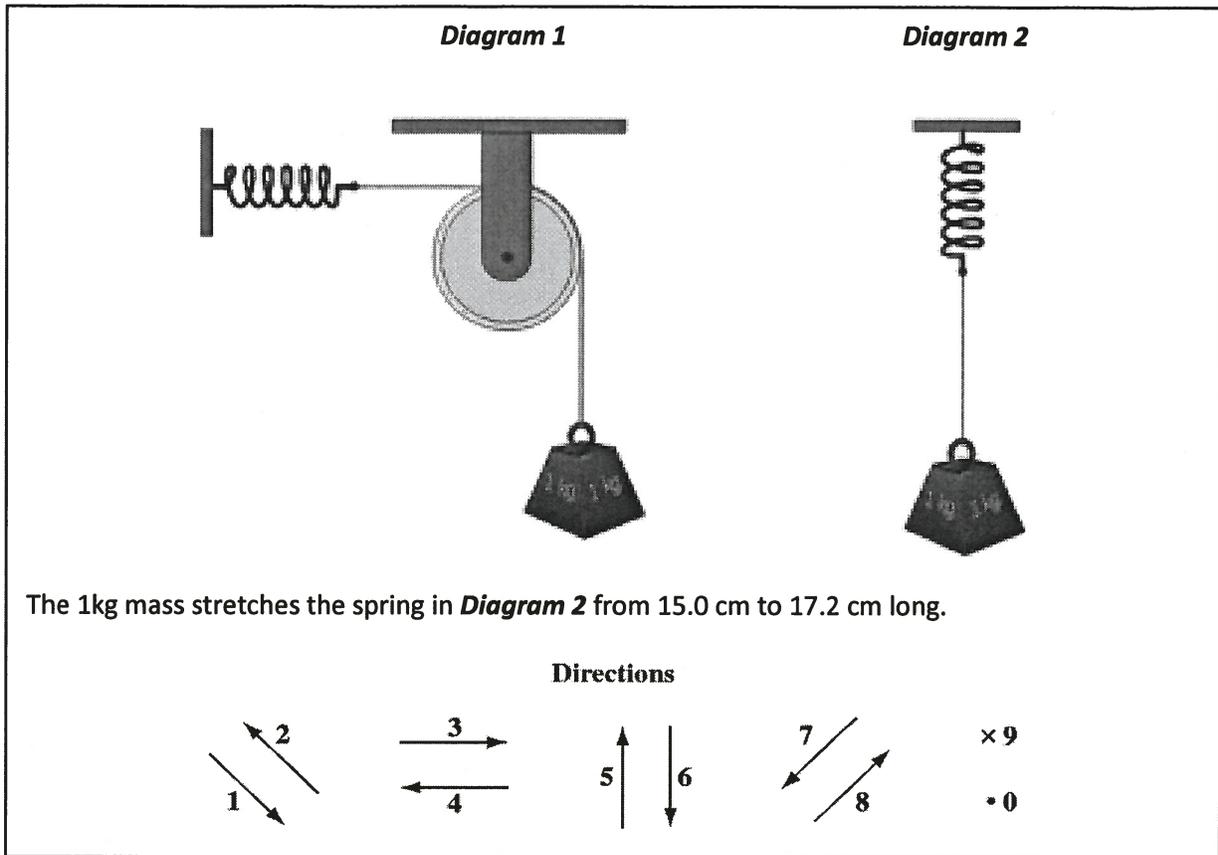
$$mg = kx$$

$$m(9.81\text{ m/s}^2) = (10.3263\text{ N/m})(0.30)$$

$$m = 0.315789\text{ kg}$$

$$m \approx 316\text{ g}$$

Use the following information to answer Q6 and Q7:



Q6: The directions of forces acting on **mass B** can be described using the numbers given above.

Direction:	<u>↓ 6</u>	<u>← 4</u>	<u>↓ 6</u>	<u>↑ 5</u>
Force:	Gravity on mass in Diagram 1	Restoring Force on spring in Diagram 1	Gravity on mass in Diagram 2	Restoring Force on spring in Diagram 2

(Record your **four digit** answer in the Numerical Response boxes below)

6	4	6	5
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Q7: The spring constant of the spring in **Diagram 2** is

- a. 5.7×10^{-1} N/m
- b. 4.5 N/m
- c. 5.7×10^1 N/m
- d. 4.5×10^2 N/m

$$\Delta x = 2.2 \text{ cm} = 0.022 \text{ m}$$

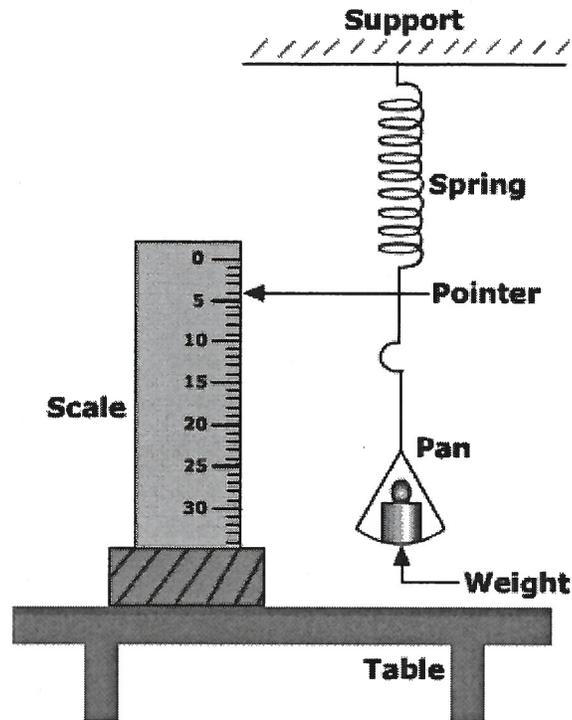
$$mg = kx$$

$$(1 \text{ kg})(9.81 \text{ m/s}^2) = k(0.022 \text{ m})$$

$$k = 445.9 \text{ N/m}$$

Use the following information to answer Q8 and Q9:

A spring of spring constant 27.0 N/m is stretched by a hanging mass, as depicted below.



The scale measures in centimeters.

Q8: What is the mass of the hanging weight?

- a. 0.09 kg
- b. 0.11 kg
- c. 9.08 kg
- d. 11.00 kg

$$\begin{aligned}
 F_g &= F_r \\
 mg &= kx \\
 m(9.81 \text{ m/s}^2) &= (27.0 \text{ N/m})(0.04 \text{ m}) \\
 m &= 0.110 \text{ kg}
 \end{aligned}$$

Q9: The spring has $a.bc \times 10^d$ Joules of elastic potential energy stored, where a , b , c , and d are _____, and _____.

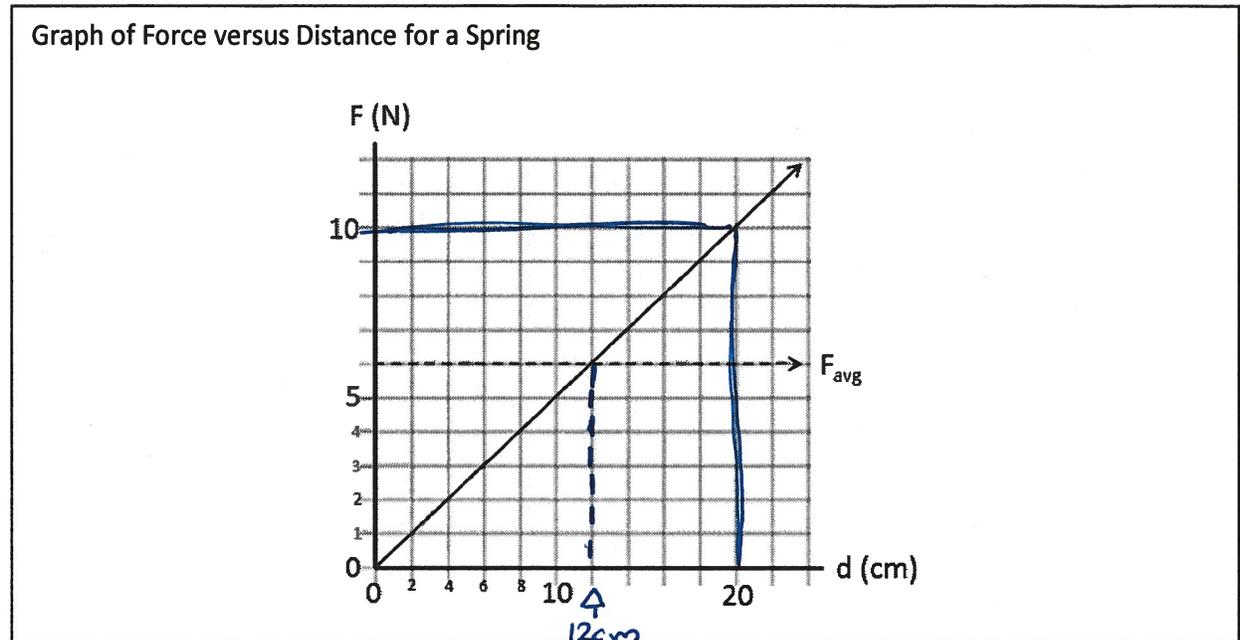
(Record your four digit answer in the Numerical Response boxes below)

2	1	6	2
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$$\begin{aligned}
 E_p &= \frac{1}{2}kx^2 \\
 &= \frac{1}{2}(27.0 \text{ N/m})(0.04 \text{ m})^2 \\
 &= 0.0216 \text{ J} \\
 &\approx 2.16 \times 10^{-2} \text{ J}
 \end{aligned}$$

Part 3 – Graphical Representations of Hooke's Law

Use the following information to answer Q10 and Q11:



Q10: What is the spring constant of this spring?

- a. 0.5 N/m
- b. 2.0 N/m
- c. 50.0 N/m
- d. 200.0 N/m

$$F = kx$$

$$10\text{ N} = k(0.2\text{ m})$$

$$k = 50\text{ N/m}$$

Q11: When stretched 12 cm, there is $a.bc \times 10^d$ Joules of elastic energy stored in the spring, where a , b , c , and d are __, __, __, and __.

(Record your four digit answer in the Numerical Response boxes below)

3	6	0	1
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$$E_p = \frac{1}{2}kx^2$$

$$= \frac{1}{2}(50\text{ N/m})(0.12\text{ m})^2 \quad \text{or} \quad E_p = \text{Area under graph}$$

$$= 0.36\text{ J} \quad = \frac{1}{2}bh$$

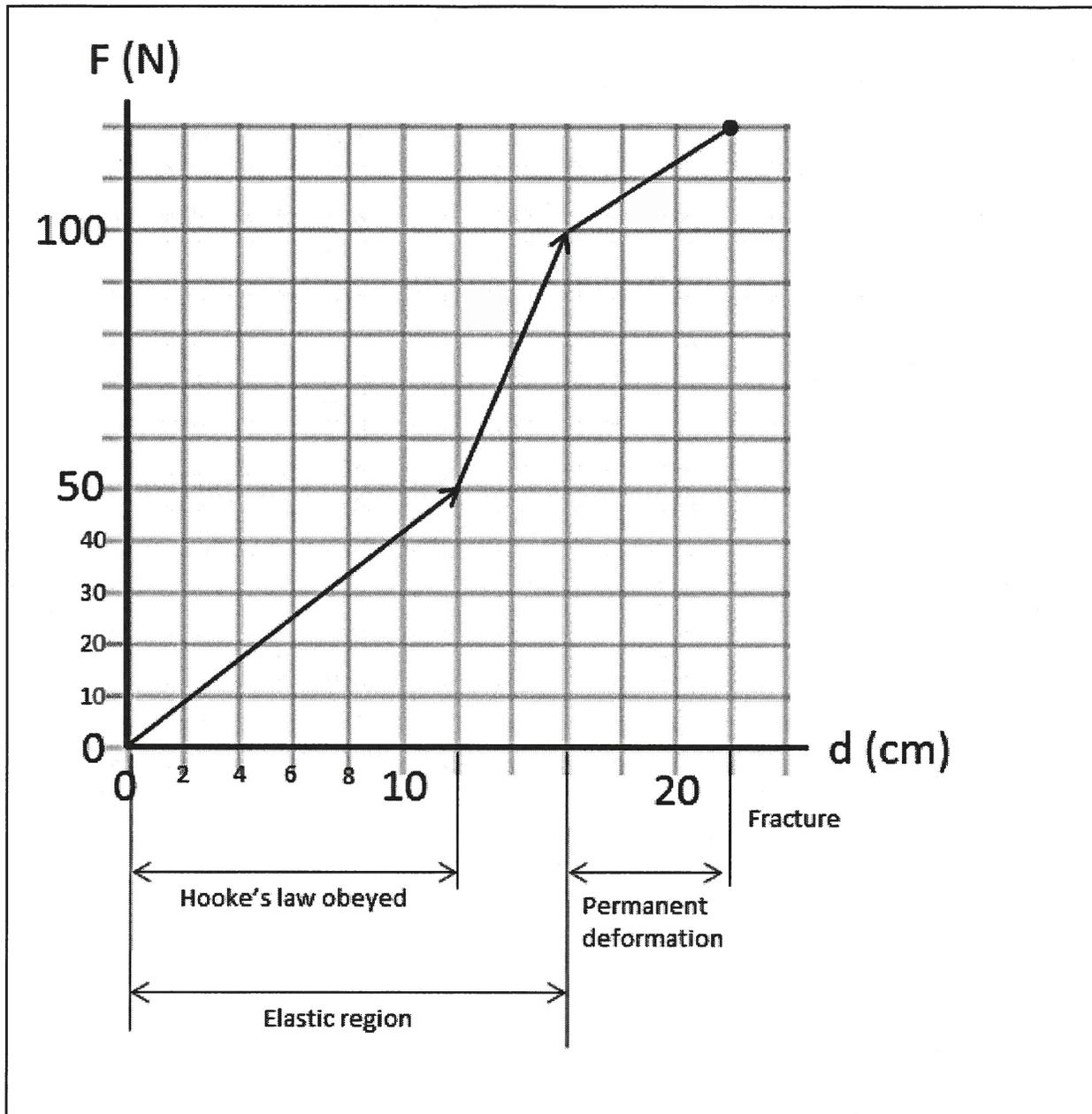
$$= \frac{1}{2}(0.12\text{ m})(6\text{ N})$$

$$= 0.36\text{ J}$$

$$E_p = 3.60 \times 10^{-1}\text{ J}$$

KEY

Use the following information to answer Q12:



Q12: The spring constant of this spring is

- a. 4.17 N/m
- b. 5.45 N/m
- c. 4.17×10^2 N/m
- d. 5.45×10^2 N/m

Look at "Hooke's law obeyed" section only.

$$F = kx$$

$$(50 \text{ N}) = k (0.12 \text{ m})$$

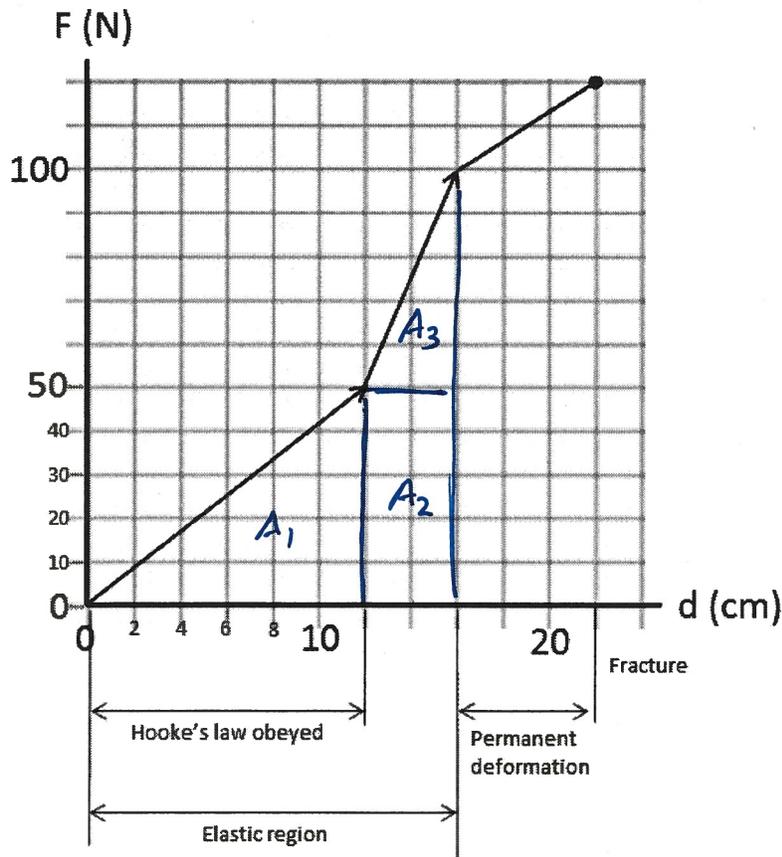
$$k = 416.\bar{6} \text{ N/m}$$

$$\approx 4.17 \times 10^2 \text{ N/m}$$

Q13: How much force is required to stretch this spring to 12 cm?

- a. 50 N *Read from graph*
- b. 51 N
- c. 60 N
- d. 75 N

Q14: (Long Answer) How much elastic potential energy is stored in the spring when it is stretched to 16 cm? (2 marks)



$E_p = \text{area under graph.}$
 Can't use $E_p = \frac{1}{2}kx^2$
 because hooke's law isn't
 obeyed from 12-16cm.

$$A_1 = \frac{1}{2}bh = \frac{1}{2}(0.12)(50) = 3$$

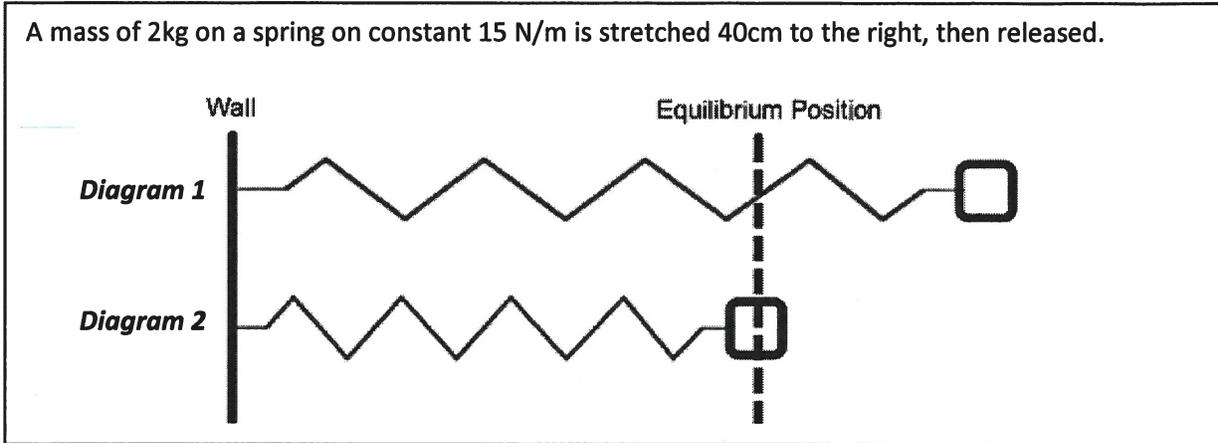
$$A_2 = L \cdot w = (0.04)(50) = 2$$

$$A_3 = \frac{1}{2}bh = \frac{(0.04)(50)}{2} = 1$$

$$A_{\text{TOT}} = 3 + 2 + 1 = \boxed{6}$$

Part 4 – Elastic Potential Energy and Conservation of Energy

Use the following information to answer Q15:



Q15: How fast is the mass travelling when it reaches the equilibrium position?

- a. 1.20×10^{-1} m/s
- b. 1.10 m/s
- c. 1.73 m/s
- d. 3.00 m/s

$$E_p \rightarrow E_k$$

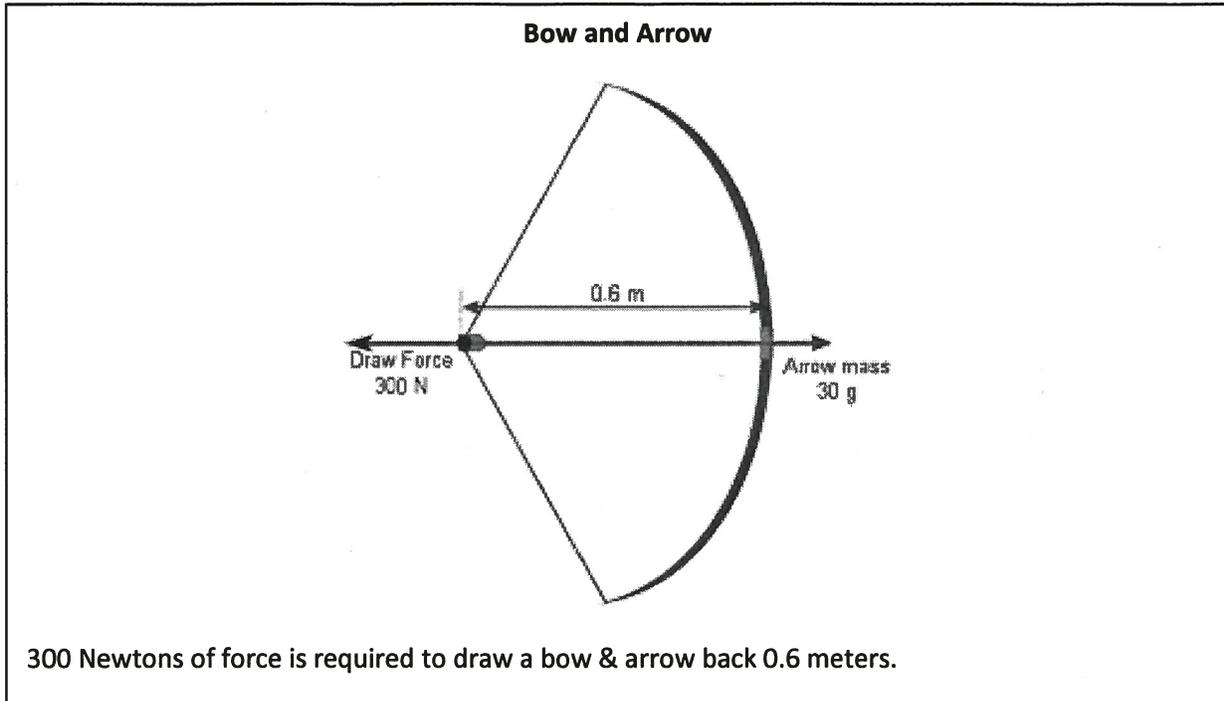
$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

$$(15 \text{ N/m})(0.4 \text{ m})^2 = (2 \text{ kg})v^2$$

$$v^2 = 1.2$$

$$v = 1.095 \text{ m/s}$$

Use the following information to answer Q16 and Q17:



Q16: (Long Answer) If a 30 g arrow is pointed vertically and released, what is the maximum height the arrow can achieve? (2 marks)

$$F = kx$$

$$300 \text{ N/m} = k(0.6 \text{ m})$$

$$\boxed{k = 500 \text{ N/m}}$$

$$E_{\text{elastic}} \rightarrow E_{\text{gravitational}}$$

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

$$\frac{1}{2}(500 \text{ N/m})(0.6)^2 = (0.03 \text{ kg})(9.81 \text{ m/s}^2)h$$

$$90 = 0.2943h$$

$$\boxed{h = 305.81 \text{ m}}$$

Q17: How fast is the arrow travelling when it is released from the bow?

- a. 50.35 m/s
- b. 66.67 m/s
- c. 77.46 m/s
- d. 141.42 m/s

$$E_p \rightarrow E_k$$

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

$$90 = \frac{1}{2}(0.03)v^2$$

$$v^2 = 6000$$

$$v = 77.46 \text{ m/s}$$

Part 5 – Work and Power

Use the following information to answer Q18:

Below is a side-by-side comparison of two popular 2015 motorcycles.



2015 Kawasaki Ninja 300 ABS

Top Speed: 170.6 kph
 0 to 96.6 kph in 5.60 seconds
 Displacement: 296 cc
 Curb Weight: 174.0 kg
 Weight with an 80.0 kg rider: 254.0 kg
 MSRP: \$5,299.⁰⁰

2015 BMW R1200GS

Top Speed: 201.2 kph
 0 to 96.6 kph in 2.90 seconds
 Displacement: 1170 cc
 Curb Weight: 238.0 kg
 Weight with an 80.0 kg rider: 318.0 kg
 MSRP: \$16,175.⁰⁰

Assume that the 0 to 96.6 kph times were measured with an 80.0 kg rider on the motorcycle.

Q18: (Long Answer) How powerful, in Watts, is each motorcycle? (4 marks)

$$96.6 \text{ kph} \div 3.6 = 26.83 \text{ m/s}$$

$$P_{Kw} = \frac{\Delta E}{\Delta t} = \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}(254\text{kg})(26.83\text{m/s})^2}{5.6\text{s}} = \frac{91,443}{5.6} = \boxed{16,329.2 \text{ W}}$$

$$P_{Bmw} = \frac{\Delta E}{\Delta t} = \frac{\frac{1}{2}mv^2}{t} = \frac{\frac{1}{2}(318\text{kg})(26.83\text{m/s})^2}{2.9\text{s}} = \frac{114,484}{2.9} = \boxed{39,477.4 \text{ W}}$$

KEY

Q19: Renatta Gass is out with her friends. Misfortune occurs and Renatta and her friends find themselves getting a *workout*. They apply a cumulative force of 1080 N to push the car 218 m to the nearest fuel station. Determine the work done on the car.

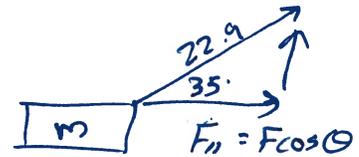
- a. 4.95 J
- b. 7.30×10^1 J
- c. 1.30×10^3 J
- d. 2.35×10^5 J

$$\begin{aligned}W &= F \cdot d \\&= (1080 \text{ N})(218 \text{ m}) \\&= 235,440 \text{ J} \\&\approx 2.35 \times 10^5 \text{ J}\end{aligned}$$

Q20: Hans Full is pulling on a rope to drag his backpack to school across the ice. He pulls upwards and rightwards with a force of 22.9 Newtons at an angle of 35 degrees above the horizontal to drag his backpack a horizontal distance of 129 meters to the right. Determine the work (in Joules) done upon the backpack.

- a. 2419.9 N
- b. 2419.9 J
- c. 2954.1 N
- d. 2954.1 J

$$\begin{aligned}W &= F_{\parallel} \cdot d \\&= (F \cos \theta) \cdot d \\&= (22.9 \cos 35)(129) \\&= 2419.9 \text{ J}\end{aligned}$$



Q21: Lamar Gant, U.S. powerlifting star, became the first man to deadlift five times his own body weight in 1985. Deadlifting involves raising a loaded barbell from the floor to a position above the head with outstretched arms. The work done by Lamar in deadlifting 300 kg to a height of 0.90 m above the ground is $a.bc \times 10^d$ J, where *a*, *b*, *c*, and *d* are __, __, __, and __.

(Record your *four digit* answer in the Numerical Response boxes below)

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$$\begin{aligned}W &= \Delta E \\E_p &= mgh \\&= (300)(9.81)(0.90) \\&= 2648.7 \text{ J} \\&\approx 2.65 \times 10^3 \text{ J}\end{aligned}$$