Physics 1020 – Fall 2018 Final Exam

PAPER NUMBER

NAME____

STUDENT NUMBER____________________________________

6th December 2018
Time: 150 minutes

INSTRUCTIONS

1. Do **all** 9 questions. Questions are valued as labelled. Question 9 is worth 16 marks.
2. **Show ALL your workings.**
3. The amount of points awarded for each part is included in the bracket next to the question.
4. Do not erase or "whiteout" your answers. Draw a line through what you think is wrong and continue your calculations.
5. Notes, textbooks, cellphones and electronic devices, with exception of a calculator are **not** permitted.
6. The final page is a formula sheet. You may remove it.
7. **A complete solution will include:**
   a. **A sketch. Where a diagram is provided it may be added to.**
   b. **Clear and logical workings, including quoting the equations you used, proper substitution of numbers and with all steps clearly indicated.**
   c. **Final answer should have units and 3 significant figures.**
8. DON'T PANIC. BREATHE. GOOD LUCK

For office use only:

1	2	3	4	5	6	7	8	9	Total

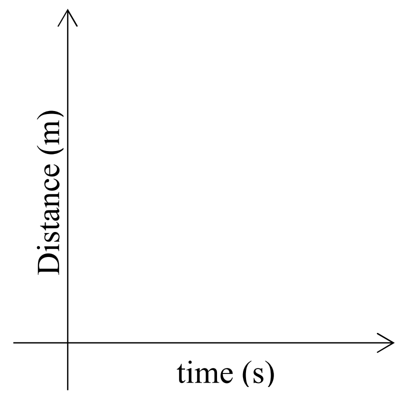
Question 1 (10 marks)

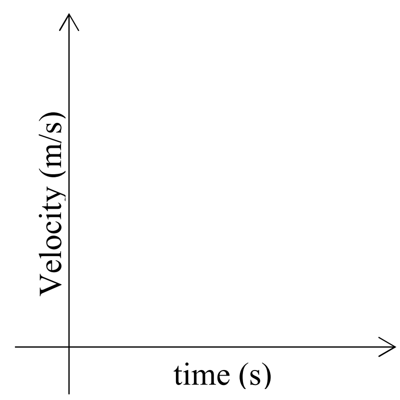
a. State Newton’s three laws *[6 points]*
b. Give an example of Newton’s third law. *[2 points]*
c. In a few lines, explain how mass is different than weight. *[2 points]*

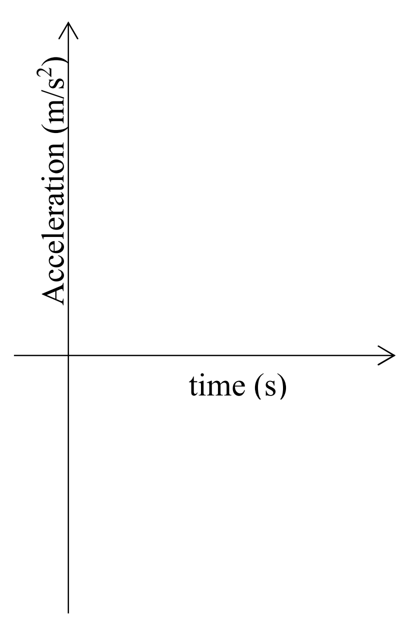
Question 2 (12 marks)

A train makes a trip as follows: The train leaves the first station and speeds up to a maximum speed of $70.0\ \text{m/s}$ over a distance of $500\ \text{m}$. The train then travels at that constant speed for $15.0\ \text{min}$. The train then begins to slow down at a rate of half the value of the initial acceleration until it comes to a complete stop at the second station.

a) What is the acceleration of the train as it speeds up? *[2 points]*
b) How far apart are the two stations? *[7 points]*
c) Sketch the forms of the distance vs time, velocity vs time, and acceleration vs time graphs on the axes provided. *[3 points]*

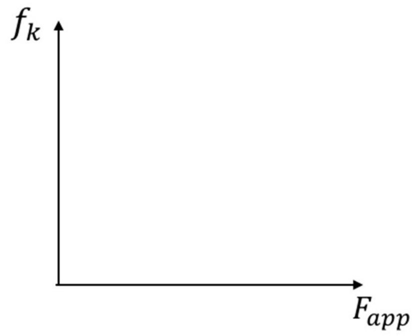






Question 3 (12 marks)

a. As you push a block from rest across a rough surface, the frictional force changes. On the axis given, sketch the frictional force as a function of the applied force. *[4 points]*



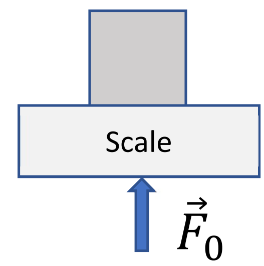
b. A block of mass 8.00 kg, sitting on a scale, starts from rest and begins to move vertically as a force $\vec{F}_0$ is applied as shown. During the motion, the reading on the scale is 65.0 N.

i. Is the block being accelerated? *[2 points]*

ii. Is the block/scale system rising or falling? *[2 points]*

iii. What is the acceleration of the block? *[2 points]*

iv. Is it possible to calculate the force $\vec{F}_0$? Justify your answer. *[2 points]*



Question 4 (10 marks)

a. One of the dangers for the orbiting International Space Station is orbiting debris. A meteoroid of mass 1.00×10^2 kg goes into a circular orbit about the earth in the same orbit as the International space station. The ISS is 340 km above the earth which has a radius of 6340 km. What is the speed of this meteoroid? *[4 points]*

$Me = 5.96 \times 10^{24}$ kg

b. Bobby Boater decides to row his boat across a river to his cabin which is 215 m directly due east from his launch point. The river is flowing due south with a speed of 2.00 m/s. On his way to the cabin Bobby judges the river speed perfectly and arrives at his cabin in a time of 40.0 s. Use the following notation:

V_{BS} = velocity of boat relative to shore
V_{BW} = velocity of boat relative to water
V_{WS} = velocity of the water relative to shore

i) Draw the vector triangle representing Bobby's trip. *[2 points]*

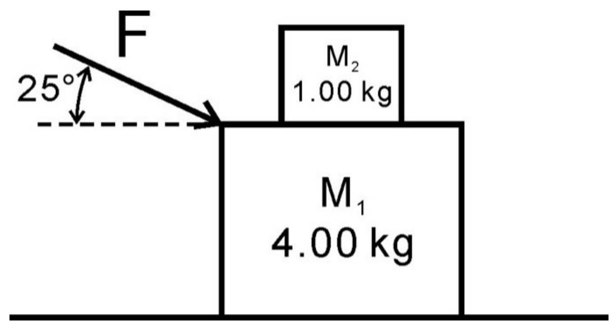
ii) At what angle did Bobby point his boat upstream in order to travel directly across to his cabin? *[2 points]*

iii) What is the velocity of Bobby's boat to the water? *[2 points]*

Question 5 (10 marks)

A 1.00 kg block sits on a 4.00 kg block which rests on a smooth table. A force of 12.0 N acts at an angle of 25.0° to the horizontal on block M_1 and causes both blocks to move with the same acceleration.

i. Draw the free body diagram for each block. *[4 points]*
Determine:
ii. the acceleration of each block, *[2 points]*
iii. the normal force exerted by the table on M_1, and *[2 points]*
iv. the magnitude of the frictional force between the two blocks. *[2 points]*



Question 6 (10 marks)

a. A 500 kg car collides with a 1500 kg truck. During the collision, is the force exerted on the car by the truck

i. greater than the force exerted on the truck by the car,
ii. equal to the force exerted on the truck by the car, or
iii. less than the force exerted on the truck by the car?

Justify your answer. *[2 points]*

b. Tarzan (who has mass 80.0 kg) is running across the jungle floor with speed 7.00 m/s as shown in Figure 1. Tarzan grabs a large bunch of bananas (15.0 kg) and grabs a vine in an attempt to swing up to his monkey who is 3.00 m above him as in Figure 2.

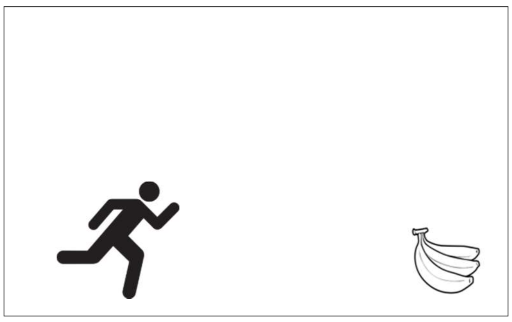


Figure 1

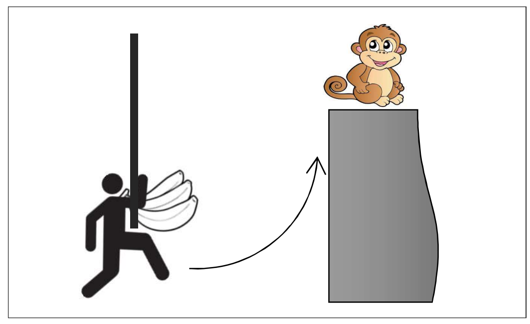


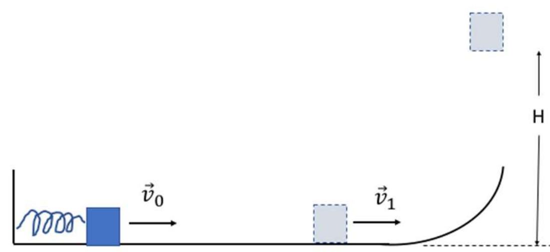
Figure 2

i. What is Tarzan's momentum before he grabs the bananas? *[2 points]*
ii. What is Tarzan's speed just after he grabs the bananas? *[4 points]*
iii. Can Tarzan swing high enough to reach his monkey? Justify your answer. *[2 points]*

Question 7 (10 marks)

a. State the Work-Energy Theorem. *[2 points]*

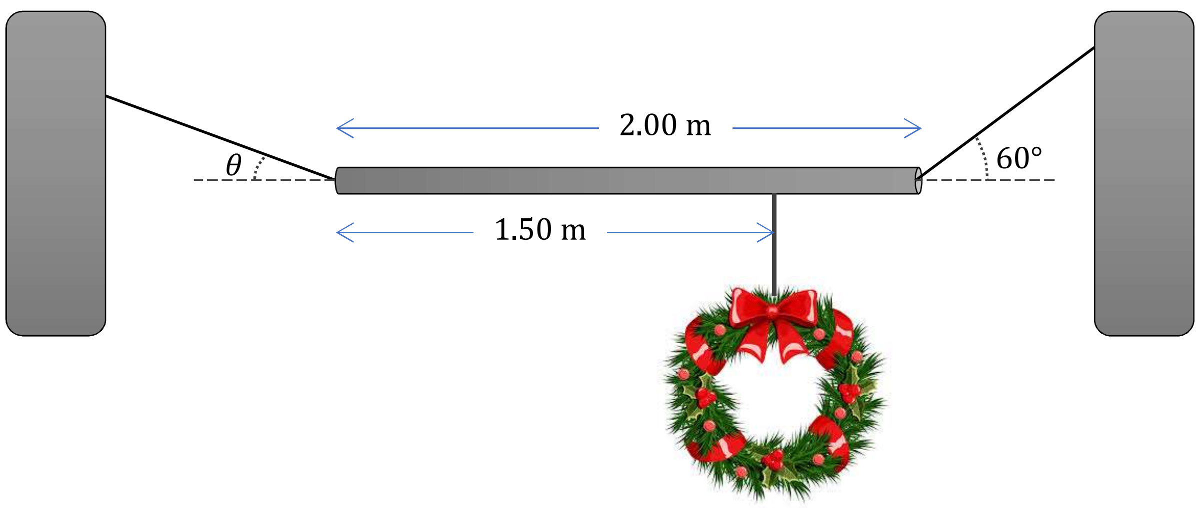
b. A 3.00 kg mass is pushed against a spring and released. If the spring constant of the spring is 7500 N/m and the spring is compressed 10.0 cm:
   i. What is the energy stored in the compressed spring? *[2 points]*
   ii. What is the maximum speed $\vec{v}_0$ of the mass? *[2 points]*
   iii. The mass then travels across a rough surface and then up a smooth ramp. The speed at the beginning of the ramp is $\vec{v}_1 = 4.00\ \mathrm{m/s}$. What is the work done by friction as the mass moves across the rough surface? *[2 points]*
   iv. The block then travels up the smooth ramp and continues on vertically. How high does it go? *[2 points]*



Question 8 (10 marks)

a. What are the conditions for static equilibrium? *[2 points]*

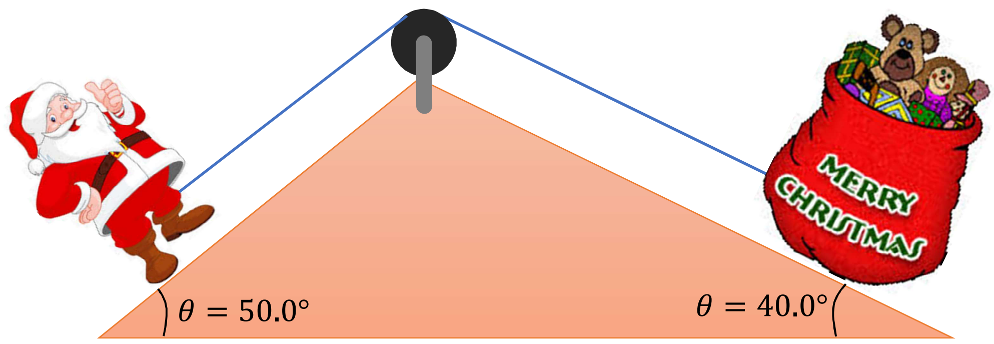
b. A 30.0 kg post is supported by two wires as shown. The post is 2.00 m long and a 5.00 kg wreath hangs 1.50 m from one end. Use the conditions for static equilibrium from part (a) to find the tension in each wire. Include a free body diagram as part of your answer. *[8 points]*



Question 9 (16 marks)

Santa (mass 90.0 kg) is attached to his bag of toys (mass 180 kg) by a light string which is hanging over an ideal pulley as shown. The coefficient of friction between the Santa and the surface and the toy bag and the surface is 0.125.
Santa and the toy bag are released from rest and begin to move.

a) Which way do Santa and the bag of toys move? Justify your answer. *[2 points]*
b) Draw free body diagrams for Santa and the bag of toys. *[4 points]*
c) Find the magnitudes of the normal forces on Santa and the bag of toys. *[2 points]*
d) Find the magnitudes of the friction forces on Santa and the bag of toys. *[2 points]*
e) Find the magnitude of the acceleration of Santa and the bag of toys and the tension in the string connecting them. *[6 points]*



$$v = v_0 + at$$

$$x = x_0 + v_{ave} t$$

$$x = x_0 + v_{0x} t + \frac{1}{2} a_x t^2$$

$$v^2 = v_0^2 + 2a(x_f - x_i)$$

$$v_{ave} = \frac{v_f + v_i}{2}$$

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

$$\vec{v} = \frac{\Delta \vec{x}}{\Delta t}$$

$$a_c = \frac{v^2}{r}$$

$$x_{CM} = \frac{\sum_{i=1}^{N} m_i x_i}{\sum_{i=1}^{N} m_i}$$

$$y_{CM} = \frac{\sum_{i=1}^{N} m_i y_i}{\sum_{i=1}^{N} m_i}$$

$$v = \frac{2\pi r}{T}$$

$$\Sigma \vec{F} = m\vec{a}$$

$$F_{s,max} = \mu_s F_N$$

$$F_k = \mu_k F_N$$

$$F = -kx$$

$$F_g = mg$$

$$F_G = \frac{G m_1 m_2}{r^2}$$

$$K = \frac{1}{2} m v^2$$

$$W = \Delta K = Fd \cos\theta$$

$$W_C = -\Delta U = U_i - U_f$$

$$U_s = \frac{1}{2} k x^2$$

$$U_G = mgy$$

$$E_f = E_i + W_{NC}$$

$$P = \frac{\Delta W}{\Delta t} = Fv$$

$$\vec{p} = m\vec{v}$$

$$\vec{I} = \Delta \vec{p} = \vec{F}_{ave} \Delta t$$

CONSTANTS

$g = 9.81 \text{ m/s}^2$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

$M_E = 5.96 \times 10^{24} \text{ kg}$

MATHEMATICAL FORMULAE

$$\vec{R} = R_x \hat{x} + R_y \hat{y}$$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$