MIDTERM EXAM-2 – v1

PHYS 201 (Spring 2018), 03/06/18

Name: Solution Key

Lab-Sect. no.:

Signature:

In taking this exam you confirm to adhere to the Aggie Honor Code:
"An Aggie does not lie, cheat, steal or tolerate those who do."

Duration: 90 minutes
Show all your work for full/partial credit!
Include the correct units in your final answers for full credit!
Unless otherwise stated, quote your results in SI units!

1.) *Multiple Choice* *(21 pts.)*

For each statement below, circle the correct answer (A, B or C, no reasoning required).

(a) When a car is driving without sliding on a circular segment of a horizontal road, the centripetal force on the car is provided by
(A) the static friction force (B) the kinetic friction force (C) the driver.

(b) When doubling the distance between two massive particles, the mutual gravitational force
(A) doubles (B) is reduced by a factor of 2 (C) is reduced by a factor of 4.

(c) In uniform circular motion, the centripetal force
(A) never does work on (B) always does work on (C) adds energy to
the revolving object.

(d) When a negative net work is done on an object, its speed
(A) increases (B) decreases (C) can go either way.

(e) The kinetic energy of a moving object
(A) is always positive (B) is always negative (C) can be positive or negative.

(f) A tennis ball bounces off a wall with the same speed as it had just before hitting the wall. In this collision
(A) only energy (B) only momentum (C) energy and momentum
is/are conserved.

(g) When two shopping carts collide and stick together thereafter,
(A) only kinetic energy (B) only momentum (C) neither
is conserved in the collision.

No.	Points
1	AS
2	AS
3	BK
4	SE
5	SE
Sum	

2.) *Satellite Motion* *(24 pts.)*

The Hubble Space Telescope moves on a circular orbit around Earth ($M_E = 6 \cdot 10^{24} kg$) at a speed of $7600\, m/s$.

(a) Calculate the radius of the telescope's orbit.

(b) Calculate its orbital period (time for one revolution).

(c) Calculate the centripetal acceleration of the telescope.

(a) $F_c = F_g$

$$\frac{mv^2}{r} = G\frac{mM_E}{r^2} \Rightarrow \boxed{r = \frac{GM_E}{v^2}} = \boxed{6.93 \cdot 10^6\, m}$$

(b) $$v = \frac{2\pi r}{T} \Rightarrow \boxed{T = \frac{2\pi r}{v}} = \boxed{5.73 \cdot 10^3\, s}$$

$$\left(\text{or} \quad T = \frac{2\pi r^{3/2}}{\sqrt{GM_E}} = 5.73 \cdot 10^3 s\right)$$

(c) $$\boxed{a_c = \frac{v^2}{r}} = \boxed{8.3\, \frac{m}{s^2}}$$

3.) *Work* (*24 pts.*)

A worker moves a box (mass 32 kg) up an inclined plane (at an angle of 25° above the horizontal) by pulling on it with a force of 140 N using a massless rope parallel to the plane surface. In the process, the box moves by 3.5 m along the plane. Neglect friction.

(a) Calculate the work done by the worker on the box.

(b) Calculate the work done by gravity on the box.

(c) Using the work-energy theorem, calculate the final speed of the box (assuming it was initially at rest).

(a) $\boxed{W_w = F_w d \cos\phi}$, $\phi = 0$

$= 140 \cdot 3.5 \cdot 1 = \boxed{490 J}$

(b) $\boxed{W_g = F_g d \cos\phi}$ $\phi = 115°$

$= 32 \cdot 9.8 \cdot 3.5 \cos(115) = \boxed{-464 J}$

(c) $\Delta K = W_{net} = 26 J$

$\Delta K = \frac{1}{2} m v_f^2 = W_{net} \Rightarrow \boxed{V_f = \sqrt{2W_{net}/m} = 1.28 \frac{m}{s}}$

4.) *Mechanical Energy Conservation* (16 pts.)

A massless spring has a spring constant of 800 N/m.

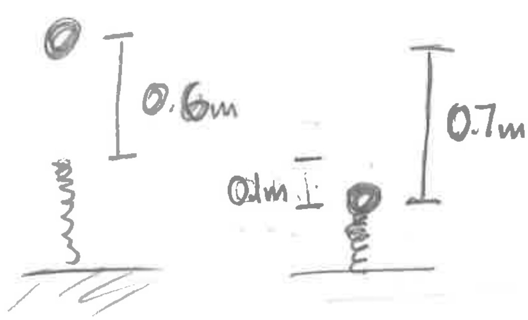
(a) How far is the spring compressed if it stores 5.4 J of potential energy?

(b) The spring is now placed vertically in relaxed position. A basketball (mass 0.625 kg) is dropped vertically down onto the spring, starting from rest at a height of 0.6 m above the upper end of the spring. What is the speed of the basketball when it has compressed the spring by 0.1 m?

(a) $U_{el} = \frac{1}{2} k x^2$

$$x = \sqrt{\frac{2U_{el}}{k}} = 0.116\,m$$

(b)



$E_i = E_f$

$mgh = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$ $h = 0.7\,m,\ x = 0.1\,m$

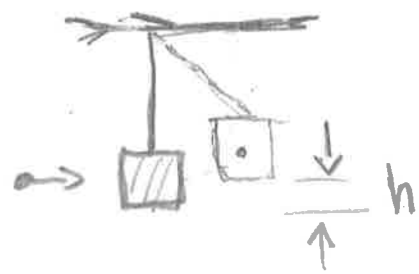
$$\Rightarrow v = \sqrt{2gh - \frac{k}{m}x^2} = 0.96\,m/s$$

5.) *Ballistic Pendulum* *(16 pts)*

A bullet (mass $8\,g$) is shot horizontally at a wood block (mass $5\,kg$) and gets stuck in it. The wood block is originally at rest, vertically suspended by a massless rope from a tree branch. The block (+bullet) swings up to a maximal vertical height of $18\,cm$ above its original position.

(a) Calculate the speed of bullet+block right after the bullet got stuck.

(b) Calculate the initial speed of the bullet just before hitting the block.



(a) $E_f = E_i$

$(m+M)gh = \frac{1}{2}(m+M)v^2$

$\Rightarrow \boxed{v = \sqrt{2gh} = 1.878\ \frac{m}{s}}$

(b) $P_i = P_f$

$m v_i = (m+M)v$

$\Rightarrow \boxed{v_i = \frac{(m+M)}{m} v = 1176\ \frac{m}{s}}$