

Your Name: _____

PHY203
Final Exam
Chapters 1-11,15
5/10/23

- Show work
- Use correct SI units
- Use scientific notation
- All answers with 3 significant figures
- use $g = 9.81 \text{ m/s}^2$

Solutions

1. A car accelerates from rest at $x=0$ at $t=0$ in the $+x$ direction at 4.00 m/s^2 for a time of 22.5 s . It then travels at constant speed for 55.0 s . Finally, it slows down until coming to rest with an acceleration of magnitude 3.00 m/s^2 .

a. For the first 22.5 s , fill out the table below:

Parameter	Known Value
x_0	0
x_f	
v_0	0
v_f	
a	4.00 m/s^2
t	22.5 s

b. Find the speed of the car after 22.5 s . 10

$$v = v_0 + a t$$

$$= 0 + (4.00)(22.5) = 90.0 \text{ m/s}$$

c. Find the distance the car has traveled after 22.5 s . 10

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$= 0 + 0 + \frac{1}{2} (4.00)(22.5)^2$$

$$= 1.01 \times 10^3 \text{ m}$$

d. For the 22.5 s to 77.5 s , fill out the table below:

Parameter	Known Value
x_0	$1.01 \times 10^3 \text{ m}$
x_f	
v_0	90.0 m/s
v_f	90.0 m/s
a	0
t	55.0 s

e. Find the total distance the car has traveled after 77.5 s. 10

$$\begin{aligned}x &= 1.01 \times 10^3 + 90.0(77.5) \\ &= 5.96 \times 10^3 \text{ m}\end{aligned}$$

f. For the period of 77.5 s to when it stops, fill out the table below:

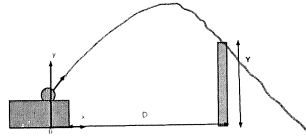
Parameter	Known Value
x_0	$5.96 \times 10^3 \text{ m}$
x_f	
v_0	90.0 m/s
v_f	0
a	-3.00 m/s^2
t	

g. Find the total time the car has been traveling before it comes to rest. 10

$$\begin{aligned}v &= v_0 + at \\ 0 &= 90.0 + (-3.00)t, \quad t = 30.0 \text{ s} \\ t_{\text{tot}} &= 30.0 + 77.5 = 107.5\end{aligned}$$

h. Find the total distance the car has traveled before it comes to rest. 10

$$\begin{aligned}x &= 5.96 \times 10^3 + 90.0(30.0) + \frac{1}{2}(-3.00)(30.0)^2 \\ &= 7.31 \times 10^3 \text{ m}\end{aligned}$$



2. A cannonball is shot from a cliff of height $H = 25.0$ m at a castle wall, as shown above. The castle wall is $Y = 85.0$ m high and a horizontal distance $D = 225$ m from the cannon. The initial horizontal component of velocity of the ball is 35.0 m/s in magnitude. Take $y = 0$ at ground level. Assume the ball just grazes the top of the wall on the way down. (Ignore air resistance.)

a. On the figure above sketch above and the trajectory of the ball from start until it hits the ground. **5**

b. Fill out the tables of known values. (Take the "final" position as when the ball grazes the wall.)

Parameter	Known Value
x_0	0
x_f	225 m
v_{x0}	35.0 m/s
v_{xf}	35.0 m/s
a_x	0
t	

Parameter	Known Value
y_0	25.0 m
y_f	85.0 m
v_{y0}	
v_{yf}	
a_y	-9.81 m/s^2
t	

c. Find the initial velocity of the cannonball and write it in vector notation using the coordinate system above. **20**

$$x: 225 = 0 + (35.0)t, \quad t = 6.43 \text{ s}$$

$$y: 85.0 = 25.0 + v_{y0}(6.43) + \frac{1}{2}(-9.81)(6.43)^2$$

$$v_{y0} = 40.8 \text{ m/s}$$

$$\vec{v}_0 = 35.0 \hat{i} + 40.8 \hat{j} \text{ m/s}$$

d. Find velocity and acceleration of the cannonball at its highest point and write them in vector notation. **10**

$$\vec{a} = -9.81 \text{ m/s}^2 \hat{j}$$

$$\vec{v} = 35.0 \text{ m/s} \hat{i}$$

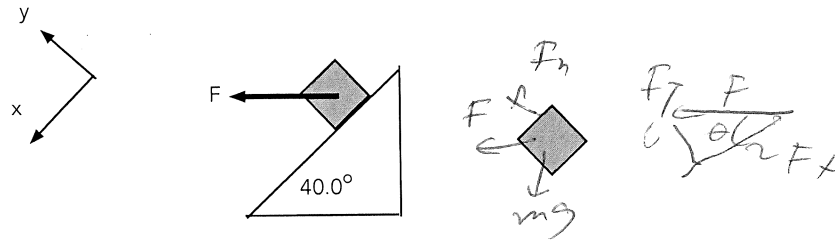
e. Find the velocity of the cannonball in vector notation just as it is about to hit the ground. **15**

$$v_y^2 = v_{y0}^2 + 2a \Delta y$$

$$= (40.8)^2 + 2(-9.81)(0 - 25.0) = 2160$$

$$v_y = -46.5$$

$$\vec{v} = (35.0 \hat{i} - 46.5 \hat{j}) \text{ m/s}$$



3. A block on a frictionless ramp is pulled with a force, F , parallel to the floor.
- Above and to the right draw a free body diagram of the block while it is sliding down the ramp. **10**
 - Write out Newton's 2nd Law for the block in both directions. **30**

$$x: F \cos 40.0^\circ + mg \sin 40.0^\circ = ma$$

$$y: F_n + F \sin 40.0^\circ - mg \cos 40.0^\circ = 0$$

Assume $m=4.00$ kg and $F = 25.0$ N.

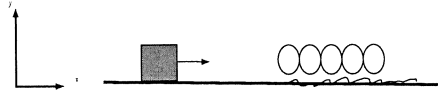
- Find the magnitude of the acceleration of the block. **10**

$$a = \frac{F \cos 40^\circ}{m} + g \sin 40^\circ$$

$$= \frac{25.0 \cos 40^\circ}{4.00} + 9.8 \sin 40^\circ$$

$$= 4.79 + 6.31$$

$$= 11.1 \text{ m/s}^2$$

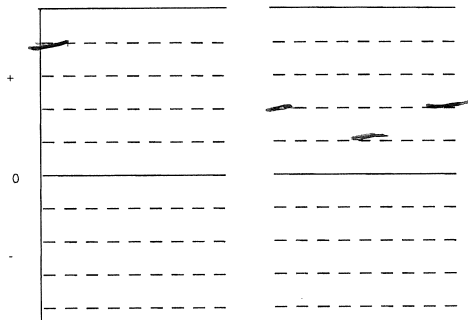


4. A block of mass 6.50 kg is sliding on a horizontal frictionless surface with a speed of 17.5 m/s. It encounters a spring with spring constant 500 N/m which is resting on a rough patch which has a coefficient of kinetic friction of 0.750. The block slides 1.25 m on the rough patch, compressing the spring by that amount, and is still moving.
- a. Sketch the final situation below: **5**



- b. Create energy bar charts: **10**

K_i U_{grav_i} U_{spring_i} E_{th_i} K_f U_{grav_f} U_{spring_f} E_{th_f}



- c. Find the speed of the block after it has slid 1.25 m on the rough surface. **35**

$$\frac{1}{2} m v_i^2 = \frac{1}{2} m v_f^2 + \frac{1}{2} k d^2 + \mu_k m g d$$

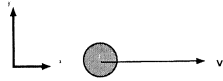
$$v_f^2 = v_i^2 - \frac{k}{m} d^2 - 2 \mu_k g d$$

$$= 17.5^2 - \frac{500}{6.5} (1.25)^2 - 2(0.750)g(1.25)$$

$$= 306.25 - 120.2 - 18.7$$

$$= 167.7$$

$$v_f = 12.9 \text{ m/s}$$



5. A block (A) of mass 7.50 kg is traveling on a frictionless surface in the +x-direction with a speed of 15.5 m/s.

a. Find the linear momentum of block A and write it in vector notation. **10**

$$\vec{p} = (7.50)(15.5) \hat{i} = 116 \text{ kg} \frac{\text{m}}{\text{s}} \hat{i}$$

b. Block A suddenly explodes into 3 pieces: B (mass 2.00 kg); C (mass 3.00 kg), and D. Piece B travels in the -x direction with a speed of 11.5 m/s; piece C travels in the +y direction with a speed of 16.5 m/s.

Draw a sketch of the situation just after the explosion.



c. List the known quantities after the collision:

Parameter	Known Value
M_B	2.00 kg
V_B	-11.5 \hat{i} m/s
M_C	3.00 kg
V_C	+16.5 \hat{j} m/s
M_D	2.50 kg

d. Find the momentum of pieces B and C in vector notation: **20**

$$\vec{p}_B = -(2.00)(11.5) \hat{i} = -23.0 \frac{\text{kg} \cdot \text{m}}{\text{s}} \hat{i}$$

$$\vec{p}_C = +(3.00)(16.5) \hat{j} = 49.5 \frac{\text{kg} \cdot \text{m}}{\text{s}} \hat{j}$$

e. Find the velocity of piece D and write it in vector notation. **20**

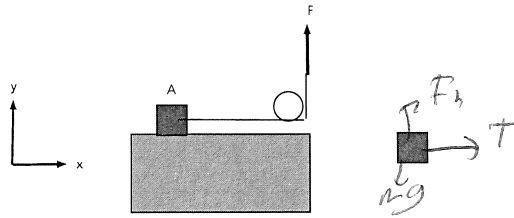
$$x: 116 = -23.0 + (2.50)V_{Dx}$$

$$V_{Dx} = 55.6 \text{ m/s}$$

$$y: 0 = 49.5 + (2.50)V_{Dy}$$

$$V_{Dy} = -19.8 \text{ m/s}$$

$$\vec{V}_D = (55.6 \hat{i} - 19.8 \hat{j}) \text{ m/s}$$



6. Block A on a frictionless table is attached a light string wrapped around a pulley. The string is being pulled straight up by a force F.

Given M_A , and M and R for the pulley (a solid disk).

a. Draw a free body diagram for the block above and to the right. **5**

b. Write out Newton's 2nd Law for block A in all directions and the torque equation for the pulley: **35**

$$x: T = m a$$

$$y: F_n - m g = 0$$

$$\tau: (F - T)R = I \alpha = \frac{1}{2} M R^2 \frac{a}{R}$$

Given $M_A = 5.50$ kg, $M = 4.00$ kg, $R = 0.500$ m, and $F = 85.0$ N.

c. Find the magnitude of the acceleration of the block. **10**

$$F - T = \frac{1}{2} M a$$

$$T = m a$$

$$F = \left(m + \frac{1}{2} M \right) a$$

$$a = \frac{85.0}{\left(5.50 + \frac{1}{2} 4.00 \right)} = 11.3 \text{ m/s}^2$$