

# Science One Physics Midterm 2

November 13, 2014

Name:

Student Number:

Bamfield Number:

Questions 1-9: Multiple Choice: 2 point each

Questions 10-12: Show your work: 19 points total

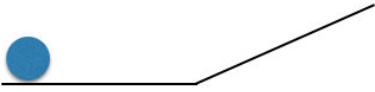
Multiple choice answers:

#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	
#9	

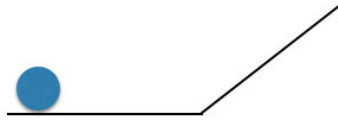
Formula sheet at the back (you can remove it)

**Question 1:** All the balls in the pictures below have equal mass and are moving to the right with equal speed. Each ball rolls up a ramp and then back down. Which ball will reach the highest vertical position?

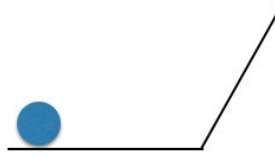
a)



b)

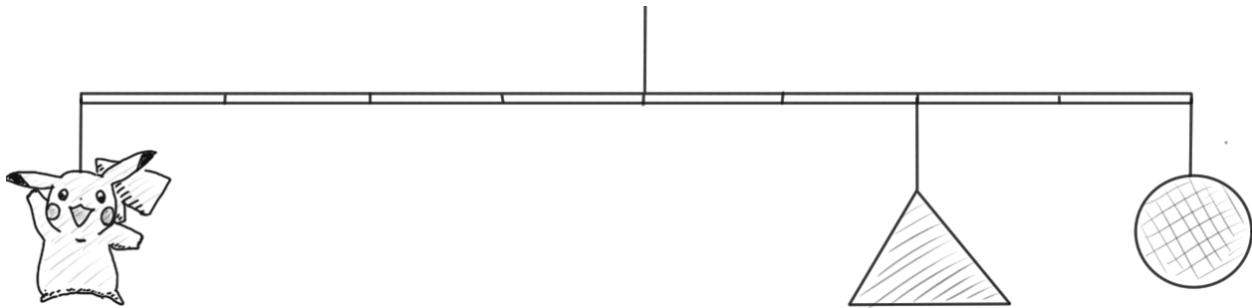


c)



d) They will all reach the same height.

**Question 2:** In the picture below, if the triangle has mass 6kg and the circle has a mass 3kg, what mass must Pikachu have for the mobile to balance?



A) 3kg    B) 6kg    C) 7.5kg    D) 9kg    E) 18kg

**Question 3:**



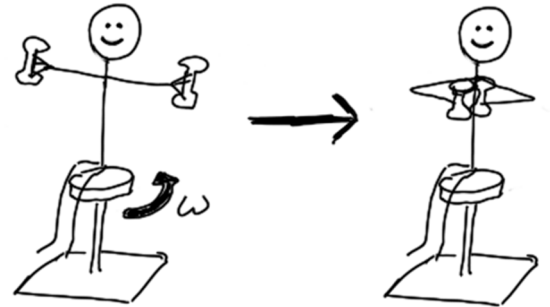
Two protons are travelling at large speeds  $v$  and  $2v$ . We can say that the momentum of the faster proton is


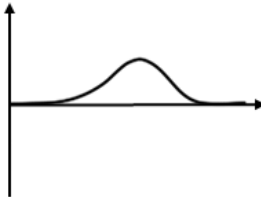
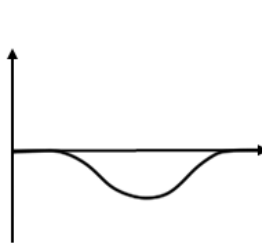
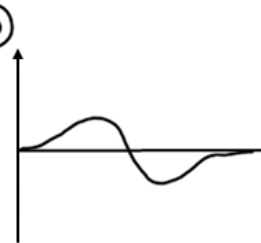
- A) Less than double the momentum of the slower proton
- B) Double the momentum of the slower proton
- C) More than double the momentum of the slower proton
- D) Any of the above could be true, depending on what  $v$  is.

**Question 4:** A ball of putty with mass  $M$  and total energy  $2 M c^2$  collides with a stationary ball of putty of mass  $M$ . If the two merge to form a single putty-ball, we can say that its mass is

- A) Less than  $2M$
- B) Equal to  $2M$
- C) Greater than  $2M$  but less than  $3M$
- D) Equal to  $3M$
- E) Greater than  $3M$

**Question 5:** Jay-Z is spinning around on a frictionless stool, holding weights with his arms extended. He then pulls the weights in towards his body and holds them there. Which of the following best represents a graph of Jay-Z's angular acceleration during this process if we assume his angular velocity is initially positive?



- (A) 
- (B) 
- (C) 
- (D) 
- (E)  $\alpha = 0$  for all  $t$

**Question 6:** A spring is extended from its equilibrium length. Assuming no atoms are lost in the process, the stretched spring is

- A) more massive than it was initially
- B) less massive than it was initially
- C) the same mass as it was initially

**Question 7:** Two balls of putty fly through the air and collide, sticking to each other to make a single ball of putty. During the collision, how many of:

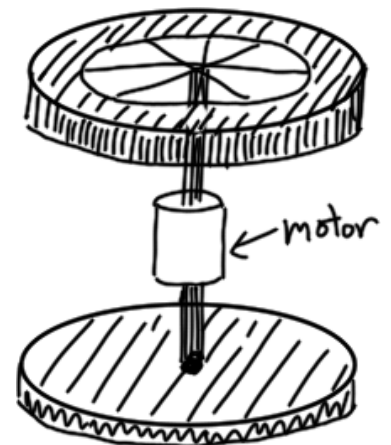
- i) momentum    ii) mechanical energy    iii) total relativistic energy

must be conserved?

- A) 0
- B) 1
- C) 2
- D) 3

**Question 8:** The object shown consists of a solid disk and a ring both with the same mass and radius, connected by a motor that makes the two ends spin relative to one another. If the object is floating in outer space with no initial angular momentum and the motor is turned on, we will find that

- A) The ring and disk will spin in opposite directions, with the ring spinning faster.
- B) The ring and disk will spin in opposite directions, with the disk spinning faster.
- C) The ring and disk will spin in opposite directions, each with the same angular speed.
- D) Neither the ring nor the disk are able to spin, since there is no external torque on the system.

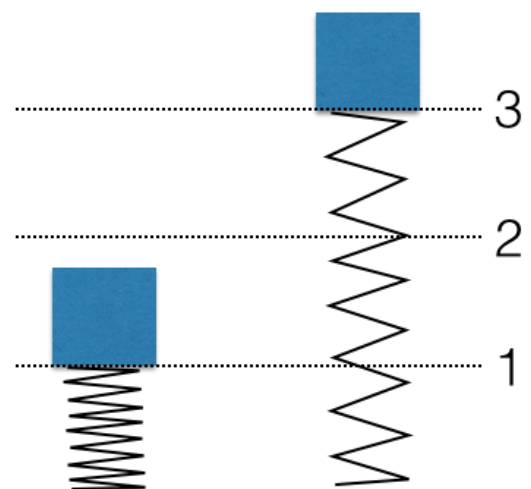


**Question 9:** The picture on the left shows a block at rest in position 1, compressing a spring. You lift the block past the point 2 where the spring is at its equilibrium length, to point 3 shown in the picture on the right.

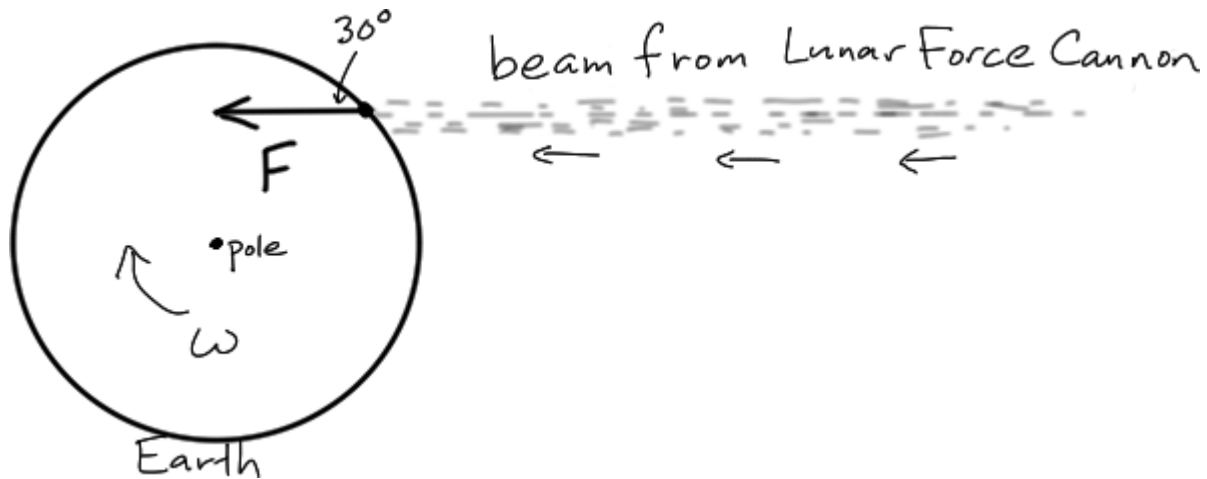
The work done by you moving the block from 1 to 2 is

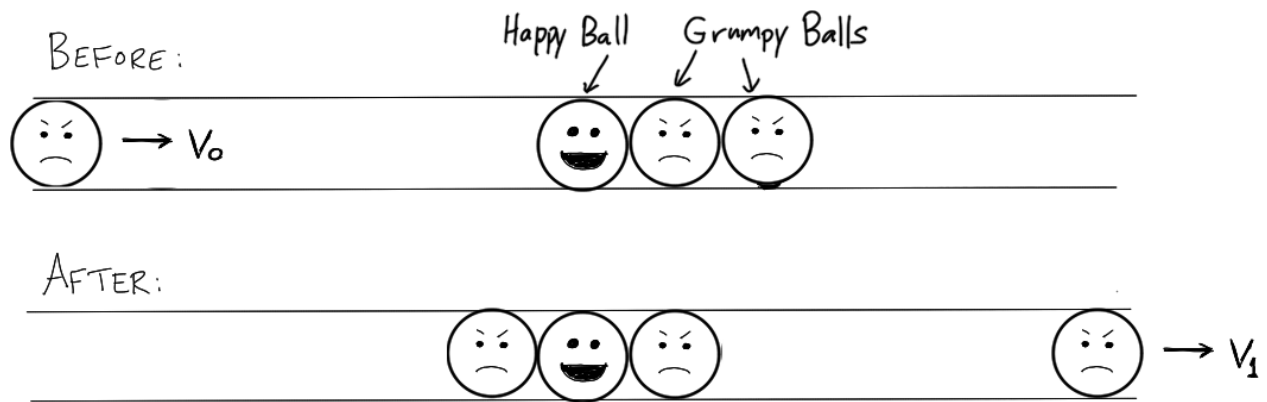
- A) the same as
- B) more than
- C) less than

the work done moving the block from 2 to 3.



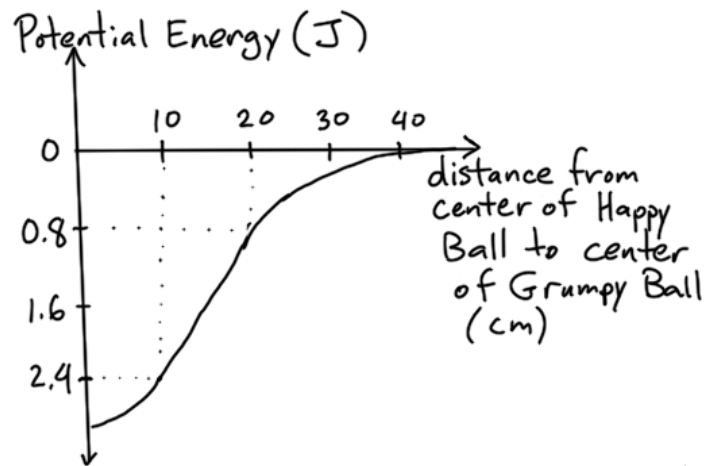
**Question 10:** A group of students from the Science One class of 2078 are sitting around one day complaining that there aren't enough hours in a day to get all their work done. So they decide to make the day longer. Using the newly built Lunar Force Cannon, the students are able to exert a constant force on the Earth as shown in the diagram. After one year, the Earth's rotation slows down enough so that the day is 25 hours long. How much force is the force cannon exerting on the Earth ( $M=6.0 \times 10^{24} \text{kg}$ ,  $R=6.4 \times 10^6 \text{m}$ )? (7 points)

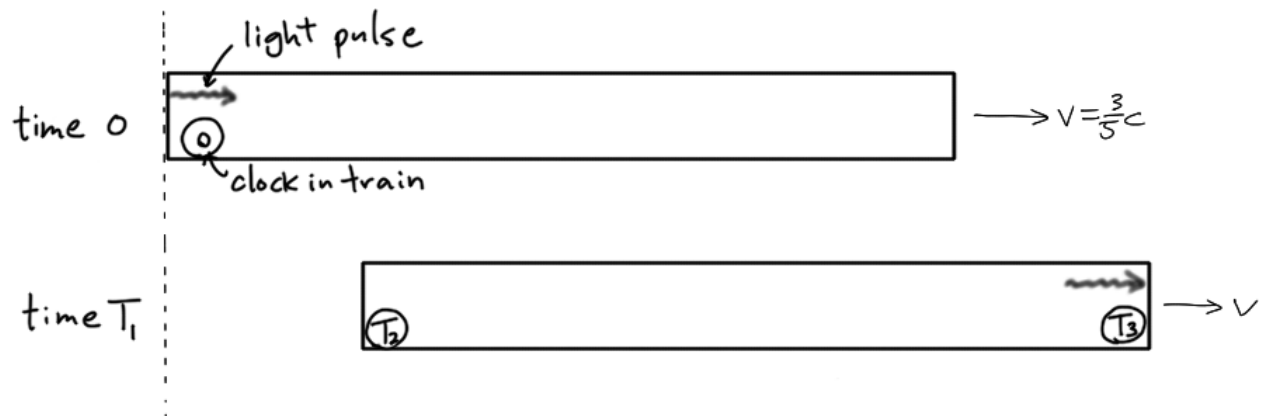




**Question 11:** Grumpy Balls have a lower potential energy the closer they are to Happy Ball, as show in the graph below.

A Grumpy Ball with initial speed  $v_0 = 1\text{m/s}$  comes in from the left as shown in the top picture. It collides with the other balls, causing the ball on the right to move off with speed  $v_1$ . If all the balls have diameter 10cm and mass 1kg, and if 0.1J is lost to heat during the inelastic collision, what is the final speed of the Grumpy Ball in the second picture? (*Note: Happy Ball is fixed in place, so momentum isn't conserved here.*) (7 points)





**Question 12:** The pictures above show a pulse of light leaving from one end of a moving train of (proper) length 30m and arriving at the other end. Observers on the train and on the track both agree that the light leaves the back of the train at time 0. **(5 points total)**

a) At what time  $T_1$  do observers on the track see the light hit the front of the train? Explain. (*Hint: the train is moving.*)

b) What is the time that is observed to pass on the clock at the back of the train during this time? This is the time  $T_2$  on the back clock in the second picture. Explain.

c) How much time do observers in the train measure for light to reach the front of the train? Explain. (*Hint: imagine you are in the train.*) This is the time  $T_3$  on the front clock in the second picture.

d) The relativity of simultaneity tells us that the front and back clocks in the train will be observed to read different times. Using your answers to b) and c), how much earlier is the time on the front clock?



## FORMULA SHEET

$$v = dx/dt \quad a = dv/dt$$

$$p \approx mv \quad (\text{if } v \ll c) \quad J = \Delta p$$

$$F = dp/dt$$

$$|F| = C v^2, \quad |F| = \mu N, \quad |F| = mg, \quad |F| = kx \quad F_x = -dU/dx$$

$$E = mgh \quad E = \frac{1}{2} mv^2 \quad E = \frac{1}{2} k (\Delta s)^2 \quad \Delta W = \vec{F} \cdot \Delta \vec{r}$$

$$L = I \omega \quad \omega = d\theta / dt \quad \alpha = d\omega / dt$$

$$\tau = dL/dt \quad \tau = F_{\text{perp}} R \quad E = \frac{1}{2} I \omega^2$$

$$a = v^2/R \quad \omega = v/R$$

$I = M R^2$  (ring, point mass),  $\frac{1}{2} M R^2$  (solid disk, cylinder),  $\frac{2}{5} M R^2$  (solid sphere),  
 $\frac{1}{3} M L^2$  (stick from one end),  $\frac{1}{12} M L^2$  (stick through middle),  $\frac{2}{3} M R^2$  (hollow sphere)

$$\gamma = (1 - v^2/c^2)^{-1/2} \quad T' = \gamma T \quad L' = L / \gamma$$

$$\vec{p} = \gamma m \vec{v} \quad E = \gamma mc^2 \quad v/c^2 = p/E \quad E^2 = p^2 c^2 + m^2 c^4$$

1 light year =  $c \times 1$  year

$c \approx 3 \times 10^8 \text{ m/s}$

$g = 9.8 \text{ m/s}^2$

**Bonus question (0 points):** Make up an angular momentum question relating to the movie "Sharknado."