Physics Midterm 2

November 14, 2013

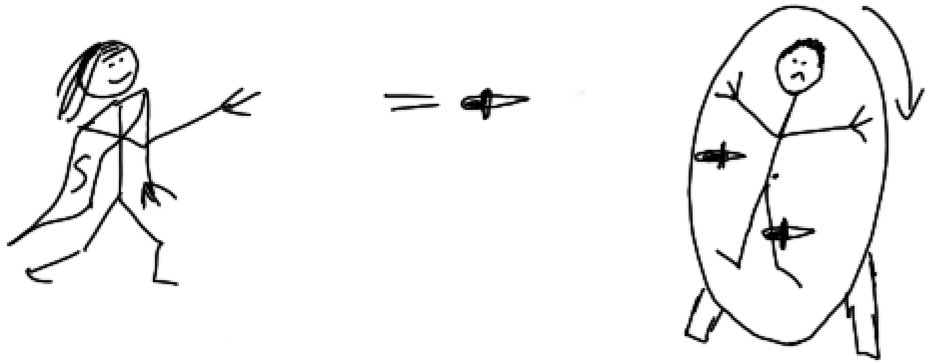
Name:
Student Number:
Bamfield Number:

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)

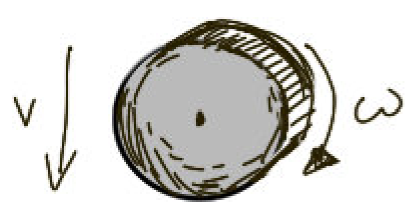


Question 1: At the circus, Sheila the Magnificent ties her assistant (Murray the Formerly-Unemployed) up to a wheel and spins it at angular velocity $\omega = 1s^{-1}$. Sheila throws five daggers which stick in the wheel, barely missing Murray. If the daggers are travelling perpendicular to the wheel when they stick, we can say that

A) the final angular velocity of the wheel will be less than $1s^{-1}$
B) the final angular velocity of the wheel will be equal to $1s^{-1}$
C) the final angular speed of the wheel will be greater than $1s^{-1}$

Ignore effects of friction, gravity, and air drag for this question.

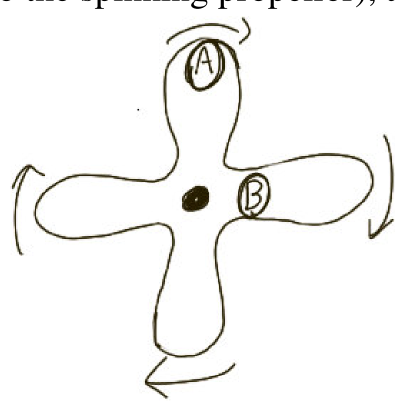
Question 2: A falling object is spinning as shown. Ignoring effects of air drag, as the object falls, its angular velocity will:

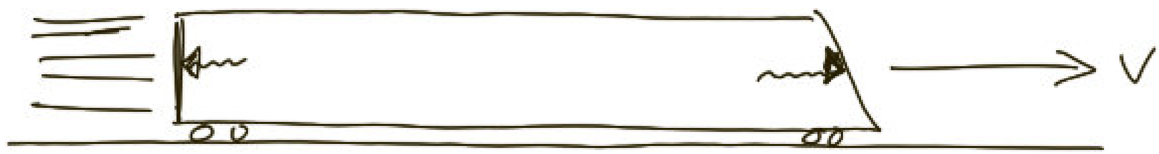


A) increase
B) decrease
C) stay the same

Question 3: In the picture below, what can we say about the speed v and angular velocity ω of A and B (which are stuck to the spinning propellor), assuming that the center of the wheel is fixed?

A) $v_A = v_B$, $\omega_A = \omega_B$
B) $v_A = v_B$, $\omega_A > \omega_B$
C) $v_A > v_B$, $\omega_A < \omega_B$
D) $v_A > v_B$, $\omega_A = \omega_B$
E) $v_A > v_B$, $\omega_A > \omega_B$





Question 4: That same old train is moving along the tracks at speed v. Observers standing near the tracks see a flash inside the train and measure the light to hit the front and back of the train at the same time *in the frame of reference of the track*. In the frame of reference of the train,

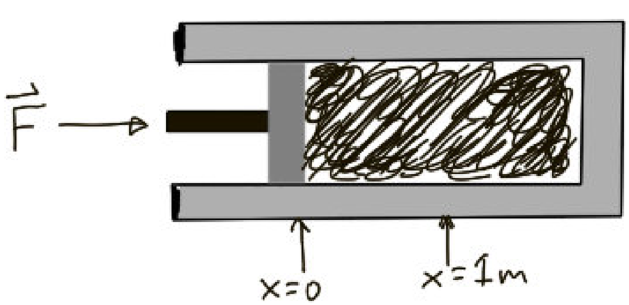
A) The light hits the front of the train first.
B) The light hits the back of the train first.
C) The light hits the front and the back of the train at the same time.
D) Any of A, B, or C could be correct, depending on where the observer is sitting.

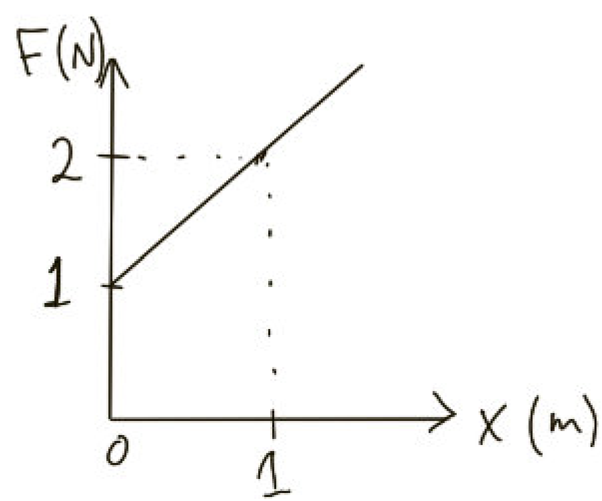
Question 5: Xondar boards the space train to go from his home planet to planet Wo☺ow, 3 light hours away. He wants to take a nap during the trip and set his alarm to wake him up just as the train arrives. If the train travels at speed 3/5c, in how many hours should he set his alarm to go off?

A) 2.4 B) 3 C) 3.75 D) 4 E) 5 F) 6.25

Question 6: A piston presses on some gas in a sealed container, compressing it. If the force applied to the piston as a function of position is shown in the graph below, how much work does it take to move the piston from x=0 to x=1m?

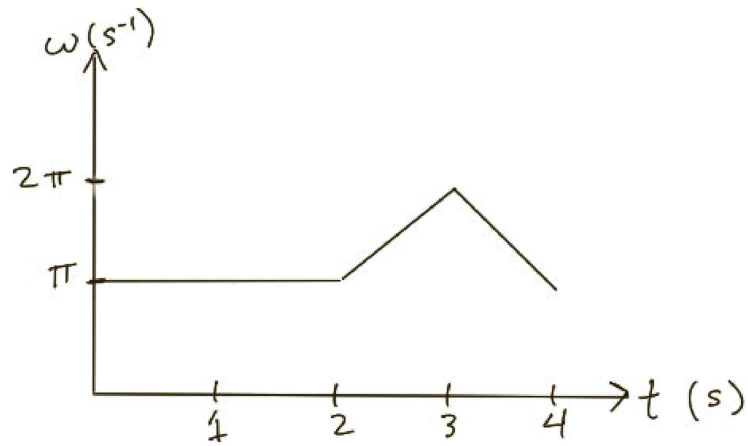
A) 0.5 J B) 1 J C) 1.5 J D) 2 J E) 3J





Question 7: Which of the following statements is true?

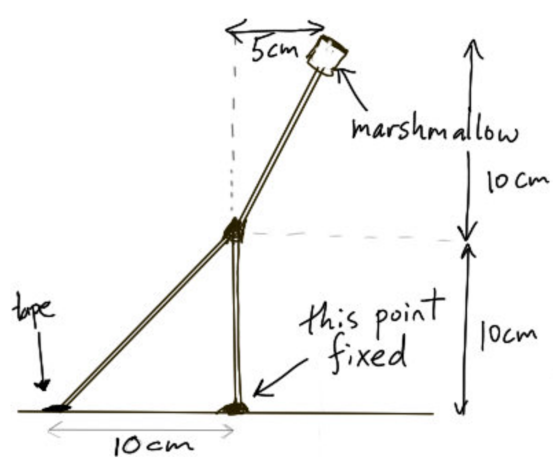
A) Since nothing can travel faster than the speed of light, there is a maximum possible momentum that an object can have.
B) If an object's momentum is nonzero in one frame of reference, it is nonzero in all frames of reference.
C) In a relativistic collision, momentum does not have to be conserved, since it can be converted into mass.
D) All of the above are true
E) None of the above are true



Question 8: The angular velocity ω for a wheel is plotted in the figure above. Starting from time 0, how long is it before the wheel makes one complete rotation?

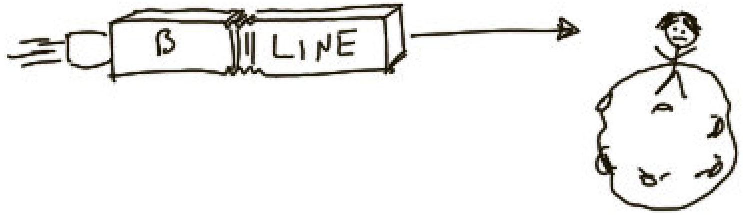
A) 1s B) 2s C) 3s D) 4s

Question 9: Some students build a rigid structure out of spaghetti and then put a marshmallow on top. If the tape can exert a maximum downward force of 0.01N on the spaghetti, approximately what is mass of the heaviest marshmallow that can be placed on the top without the structure tipping over? Ignore the mass of the spaghetti.

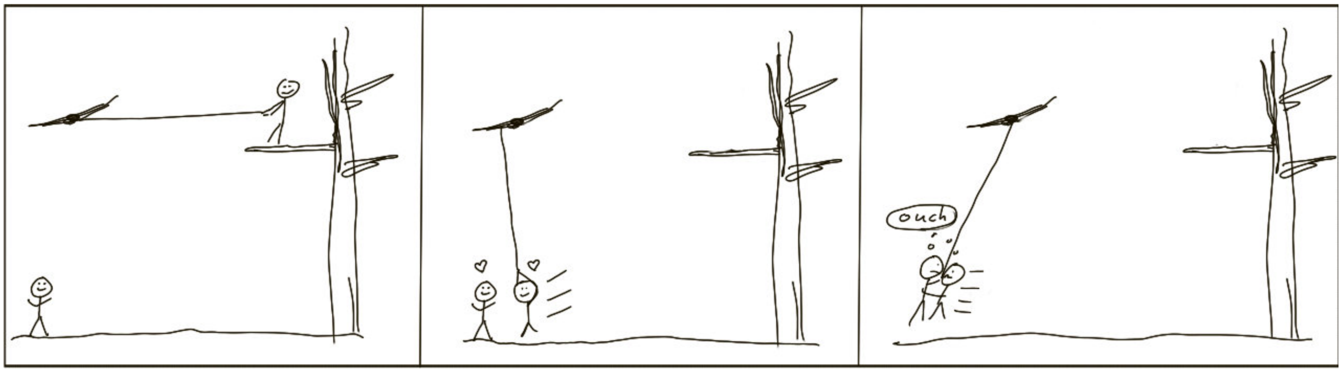


A) 0.5g B) 1g C) 2g D) 3g E) 4g

Question 9: The Starship Enterprise (mass M) moving at speed v=3/5c collides with a small black hole (also of mass M) that is initially stationary, forming a larger black hole. Determine the mass and speed of the new black hole. (*Hint: for the purposes of this question, there is nothing special about black holes compared to other objects.)*
6 points



Question 12: Noreen is waiting on her asteroid for the interplanetary B-line space-bus. When the bus is approaching she observes the lights on the bus to have wavelength 500nm. Unfortunately, the bus is full, so it doesn't even slow down. It takes only 10^{-7} seconds from when the front of the bus passes her to when the back of the bus passes her. When the bus is flying away, she observes the lights on the bus to have wavelength 1000nm. How long the bus (in its own frame of reference)? **5 points**



Question 12:

a) Tarzan swings on a vine of length 8m that is initially horizontal. When the vine is vertical, he and Jane grab each other, and together they swing back upwards. If Tarzan and Jane have the same mass M and the mass of the vine can be ignored, to what height do they swing? **5 points**

b) Estimate how long it takes Tarzan to swing down and reach Jane. **3 points**

Bonus question (0 points): What does the fox say?

FORMULA SHEET

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

$p \approx mv$ (if $v \ll c$) $J = \Delta p$

$F = dp/dt$

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

$E = mgh$ $E = ½\,mv^2$ $E = ½\,k\,(\Delta s)^2$ $\Delta W = \vec{F} \cdot \Delta\vec{r}$

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

$\tau = dL/dt$ $\tau = F_{perp}\,R$ $E = ½\,I\,\omega^2$

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

$I = M\,R^2$ (ring, point mass), $½\,M\,R^2$ (solid disk, cylinder), $^2/_5\,M\,R^2$ (solid sphere), $^1/_3\,M\,L^2$ (stick from one end), $^1/_{12}\,M\,L^2$ (stick through middle), $^2/_3\,M\,R^2$ (hollow sphere)

$\gamma = (1 - v^2/c^2)^{-1/2}$ $T' = \gamma\,T$ $L' = L/\gamma$ $\lambda_{obs} = \lambda\sqrt{\frac{1+v/c}{1-v/c}}$

$u' = (u - v)/(1 - uv/c^2)$

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

1 light year $= c \times 1$ year
$c \approx 3 \times 10^8$m/s
$g = 9.8$ m/s^2