| | | Surname | | Type |
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| Group Number | | Name | | A |
| List Number | | e-mail | | |
| Student ID | | Signature | | |

**ATTENTION:Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.**

**1.** Which of the following is not one of the fundamental physical quantities in the SI system?

(a) force (b) length (c) mass (d) time (e) All of the these are fundamental physical quantities.

**Questions 2-5**

Time dependent position vectors of two particles are given by $\vec{a} = t\hat{i} + 2\hat{j} + \hat{k}$ and $\vec{b} = \hat{i} - t\hat{j} + 2\hat{k}$. Here t represents time in seconds and the magnitudes of vectors $\vec{a}$ and $\vec{b}$ are in meters.

**2.** At which instant in time $\vec{a}$ is perpendicular to $\vec{b}$ ?

(a) t=4 s (b) t=5 s (c) t=2 s (d) t=1 s (e) t=3 s

**3.** Which of the following is a unit vector, that is perpendicular to the plane spanned by vectors $\vec{a}$ and $\vec{b}$, at t=0?

(a) $\frac{2\hat{i}-3\hat{j}+5\hat{k}}{\sqrt{36}}$ (b) $\frac{4\hat{i}+3\hat{j}+2\hat{k}}{\sqrt{23}}$ (c) $\frac{2\hat{i}+4\hat{j}-2\hat{k}}{\sqrt{24}}$ (d) $\frac{4\hat{i}+\hat{j}-2\hat{k}}{\sqrt{21}}$ (e) $\frac{\hat{i}+\hat{j}-2\hat{k}}{\sqrt{6}}$

**4.** Which of the following is the distance between the two particles at t=3 s?

(a) 30 m (b) 28 m (c) $\sqrt{30}$ m (d) $\sqrt{29}$ m (e) $\sqrt{28}$ m

**5.** Which of the following is the position vector of the first particle relative to the second one at t=3 s?

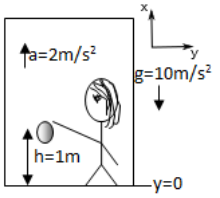
(a) $2\hat{i} + 5\hat{j} - \hat{k}$ (b) $3\hat{i} + 4\hat{j} - 1\hat{k}$ (c) $4\hat{i} + 5\hat{j} - 3\hat{k}$ (d) $4\hat{i} + 3\hat{j} + 2\hat{k}$ (e) $2\hat{i} - 3\hat{j} + 5\hat{k}$

**6.** A ball is thrown vertically upward, reaches its highest point and falls back down. Which of the following statements is true?

(a) The acceleration is always in the direction of motion. (b) The acceleration is always directed down. (c) At the highest point the velocity and acceleration of the particle are both nonzero. (d) The acceleration is always directed up. (e) The acceleration is always opposite to the velocity.

**Questions 7-11**

A girl is holding a ball as she steps onto a tall elevator on the ground floor of a building. She holds the ball at a height of 1 meter above the elevator floor. The elevator begins accelerating upward from rest at 2 m/s$^2$ in +y direction. After the elevator accelerates for 10 seconds (Take g = 10 m/s$^2$, $6^{-1/2} = 0.4$),




**7.** Find the speed of the elevator.

(a) 25 m/s. (b) 15 m/s. (c) 20 m/s. (d) 5 m/s. (e) 30 m/s.

**8.** Find the height of the floor of the elevator above the ground.

(a) 75 m. (b) 100 m. (c) 200 m. (d) 150 m. (e) 50 m.

At the end of 10 s, the girl releases the ball from a height of 1 meter above the floor of the elevator. If the elevator continues to accelerate upward at 2 m/s$^2$,

**9.** Find the acceleration of the ball relative to the elevator.

(a) -8 m/s$^2$ (b) -12 m/s$^2$ (c) 12 m/s$^2$ (d) -10 m/s$^2$ (e) 8 m/s$^2$

**10.** What is the time needed the ball hits the floor after the ball is released ?

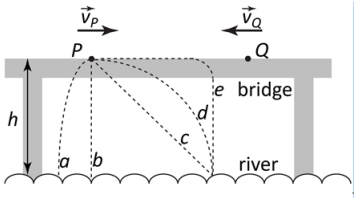
(a) 0.4 s (b) 0.2 s (c) 2 s (d) 2.5 s (e) 0.3 s

**11.** What is the elevator's approximate height (h) above the ground when the ball hits the elevator's ground?

(a) 8 m. (b) 4 m. (c) 174 m. (d) 100 m. (e) 108 m.

**Questions 12-15**

Harry is running with a constant speed $v_P = 3$ m/s across a horizontal bridge of height $h = 5$ m as shown in the figure. When he passes point P, he opens his hand and drops a rock into the river. In the following calculations, take $g = 10\,m/s^2$.




**12.** If you are standing at point P, which one of the trajectories shown in the figure best describes the path of the rock you are observing?

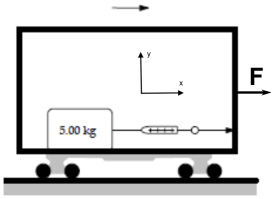
(a) Path b (b) Path a (c) Path e (d) Path d (e) Path c

**13.** What horizontal distance does the rock travel from point P to the point where it hits the river?
(a) 6 m (b) 3 m (c) 10 m (d) 5 m (e) 1.5 m

**14.** What is the speed of the rock at the point where it hits the river?
(a) $\sqrt{109}$ m/s (b) 3 m/s (c) 13 m/s (d) 10 m/s (e) 5 m/s

**15.** Suppose Sally is running in the direction opposite to Harry with a constant speed $v_Q = 2$ m/s . She passes point Q located 2 m to the right of point P at the same time when Harry passes point P, opens her hand, and drops another rock into the river. What is the horizontal distance between the points where the two rocks dropped by Harry and Sally hit the river?
(a) 3 m (b) 2 m (c) 0 (d) 5 m (e) 1 m

**Questions 16-18**




A 5kg mass attached to a spring scale rest on a frictionless, horizontal surface. The spring scale attached to the front end of a boxcar, reads 20 N when the car is in motion and 0 N when it is at rest. The mass of boxcar is 10 kg.

**16.** In which type of frame of reference is Newton's first law obeyed?

I. Noninertial frame of reference. II. Inertial frame of reference. III. Frame of reference that is accelerating. IV. Frame of reference that is moving along a curve.

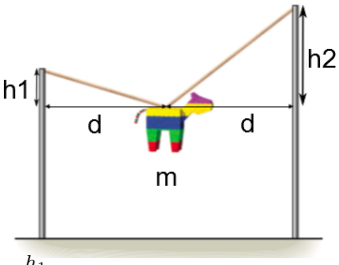
(a) none of them (b) only III (c) only II (d) I and III (e) II and III

**17.** Determine the acceleration of the car.
(a) $-\frac{4}{3}\hat{i}$ m/s$^2$ (b) $\frac{4}{3}\hat{i}$ m/s$^2$ (c) $4\hat{i}$ m/s$^2$ (d) $2\hat{i}$ m/s$^2$ (e) $-4\hat{i}$ m/s$^2$

**18.** What will the spring scale read if the car moves with constant velocity?
(a) 0 N (b) 10 N (c) 4 N (d) 6 N (e) $-20$ N

**Questions 19-20**

A toy horse of mass $m$ is attached to a rope of negligible mass that is strung between the tops of two vertical poles as shown in the figure.

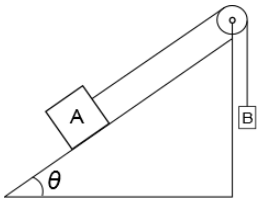



**19.** What is the relation between the tensions in the left ($T_1$) and right ($T_2$) sides of the rope?
(a) $T_1 = T_2\frac{h_2^2}{h_1^2}$ (b) $T_1 = T_2\sqrt{\frac{h_1^2+d^2}{h_2^2+d^2}}$ (c) $T_1 = T_2\frac{h_1^2}{h_2^2}$ (d) $T_1 = T_2$ (e) $T_1 = T_2\sqrt{\frac{h_2^2+d^2}{h_1^2+d^2}}$

**20.** What is $T_1$?
(a) $T_1 = 2mg\frac{\sqrt{h_1^2+d^2}}{h_1+h_2}$ (b) $T_1 = mgh_1$ (c) $T_1 = mg\frac{\sqrt{h_1^2+d^2}}{h_1+h_2}$ (d) $T_1 = \sqrt{\frac{h_1^2+d^2}{h_2^2+d^2}}$ (e) $T_1 = mg\frac{h_1}{h_2}$

**Questions 21-24**

Block A of mass 2.0 kg is on an inclined plane with inclination $\theta = 37^o$ ($\sin\theta = 3/5$). It is attached with a string passing over a massless and frictionless pulley to block B of mass 1.0 kg. The coefficients of static and kinetic friction between block A and the inclined plane are $\mu_s$=0.6 and $\mu_k$=0.5, respectively. Gravitational acceleration is assumed to be 10 $m/s^2$. The system is released from rest. Assume that the static friction case holds:




**21.** What is the static friction force on block A?
(a) 9.6 N downhill (b) 9.6 N uphill (c) 0 (d) 2 N downhill (e) 2 N uphill

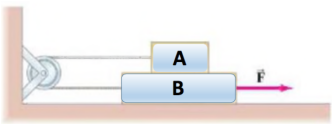
**22.** Is the static friction assumption valid or not and why?
(a) Yes, $f_s < \mu_s$N (b) Yes, $f_s = \mu_s$N (c) Yes, $f_s > \mu_s$ (d) No, $f_s > \mu_s$ (e) No, $f_s < \mu_s$

Now the blocks are given an initial velocity (hanging block downward, 2.0 kg block upward) of 1.0 m/s.

**23.** What is the acceleration of the hanging block in $m/s^2$
(a) 13/3 upward (b) 10/3 downward (c) 13/3 downward (d) 0 (e) 10/3 upward

**24.** How much will the blocks move until they stop (in meters)?
(a) 1 (b) they will not stop (c) 1/2 (d) 13/6 (e) 3/26

**25.** Consider the system shown in figure on the right. Block A sits on top of block B which is on a horizontal surface. The block B is pulled to the right with a force F. The coefficient of kinetic friction between all surfaces is $\mu_k$. What is the acceleration of the system? Hint: Assume that the force is enough to move the system.




(a) $\mu_k(3m_A + m_B)g$ (b) $\frac{F-\mu_k(m_A+3m_B)g}{(m_A+3m_B)}$ (c) $\frac{2F-\mu_k(m_A+m_B)g}{(m_A+m_B)}$ (d) $\frac{F-\mu_k(3m_A+m_B)g}{(m_A+m_B)}$ (e) $\mu_k(m_A + 3m_B)g$