a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics
Circular Motion

Science and Mathematics
Education Research Group

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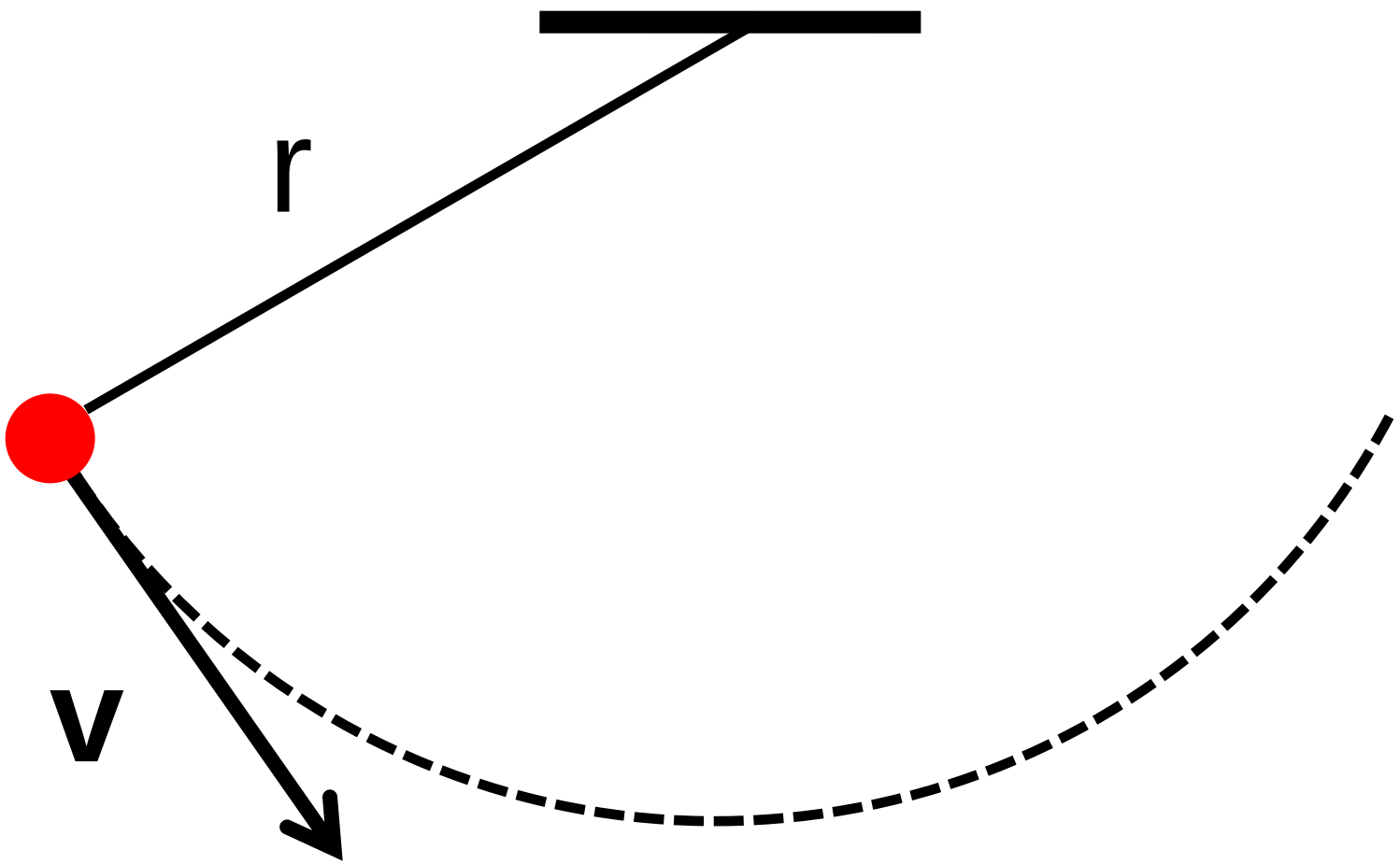
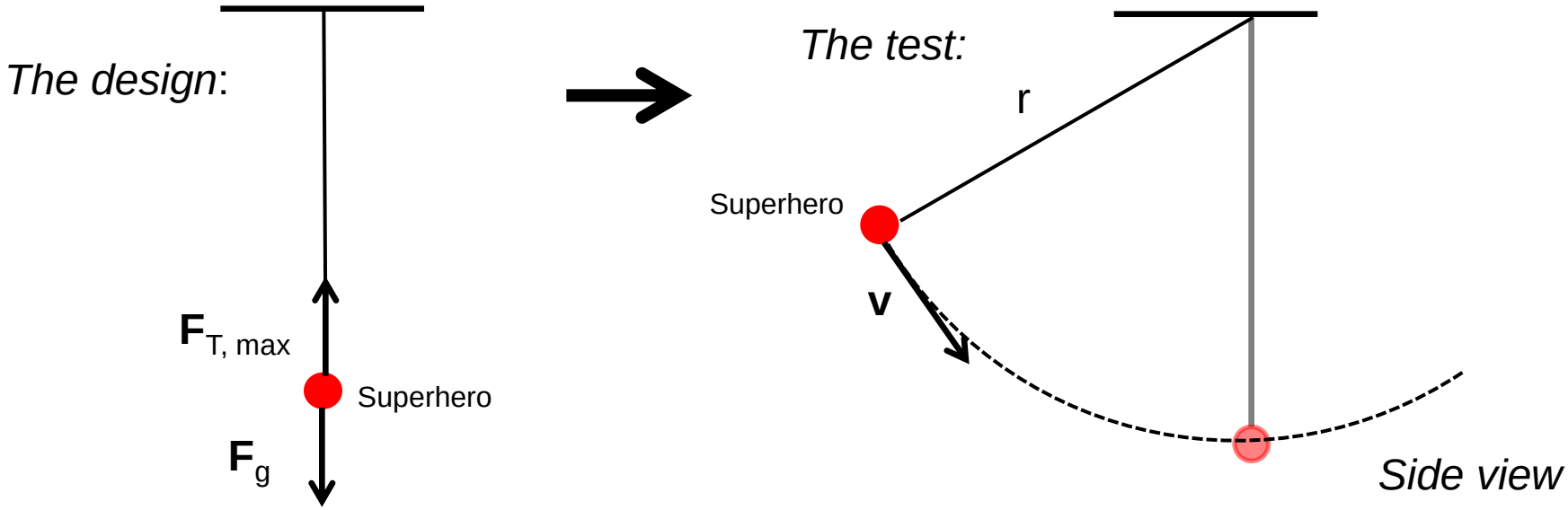
Superhero Physics



The Scenario

A superhero is designing a new rope-like gadget that will allow him to swing from building to building. The gadget is designed so that the rope is just strong enough to hold the superhero's weight when he hangs on it (without swinging). The superhero decides that the gadget is safe and tries swinging on the rope. Is the superhero able to swing safely across?

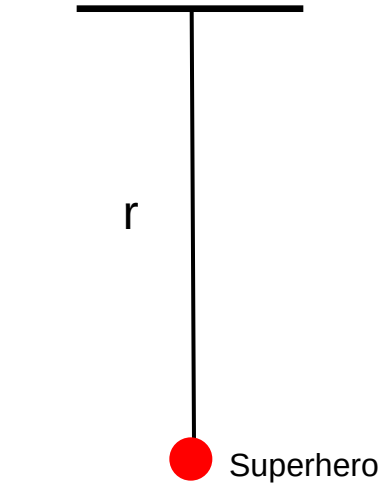


Superhero Physics I

Consider the superhero when he is hanging onto the rope at rest. Which of the following is the correct free-body diagram of the superhero?

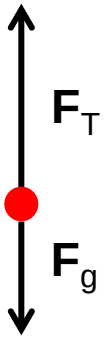
$\mathbf{F}_T$ = tension force

$\mathbf{F}_g$ = gravitational force

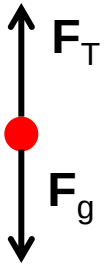


Side view

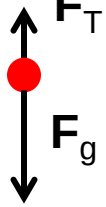
A.



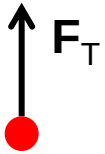
B.



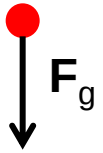
C.



D.

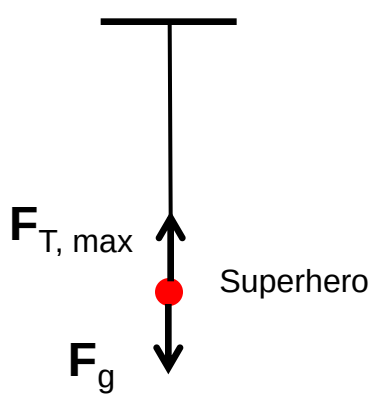


E.



Solution

Answers: B

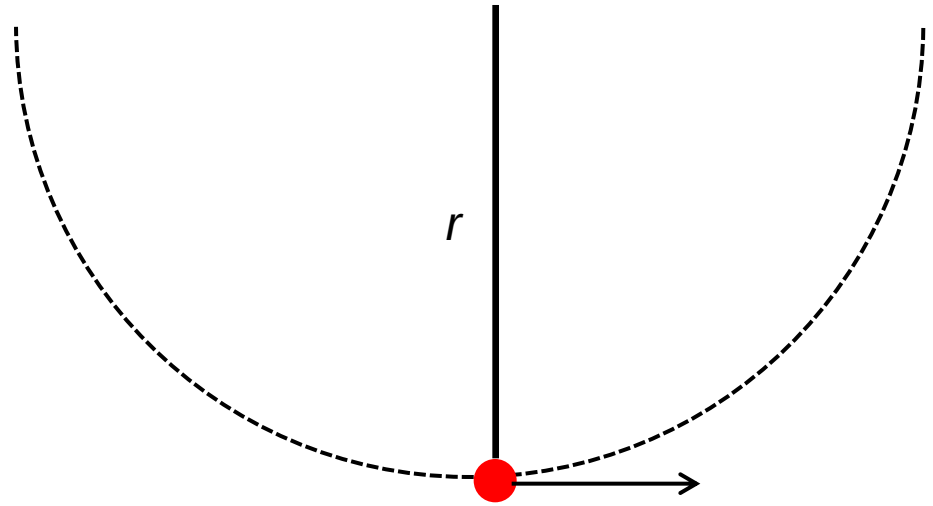


Justification: The superhero is not moving or accelerating so there must be no net force. There are only 2 forces acting on the superhero, the force of gravity from the earth pulling him down and the tension from the rope holding him up. These two forces must be equal in magnitude.

Additionally, the rope designed by the superhero is only strong enough to hold a force of *mg*. Any tension force larger than this will break the rope.

Superhero Physics II

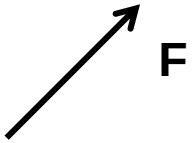
Consider the superhero at the lowest point of the swing. Assume the rope is *r* meters long and the superhero is moving at speed *v*. What is the direction of the net force on the superhero at this moment?



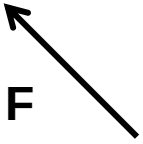
Side view

A. No net force

B. 

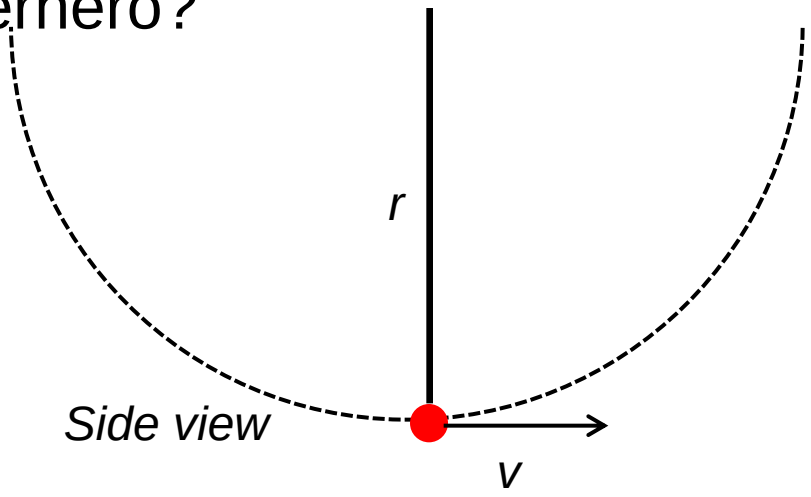
C. 

D. 

E. 

Superhero Physics III

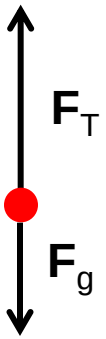
Which of the following is the correct free-body diagram of the superhero?

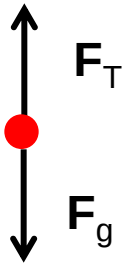


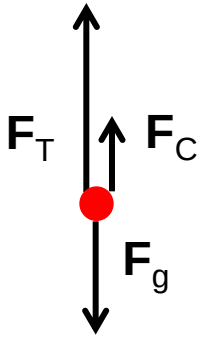
$\mathbf{F}_T$ = tension force

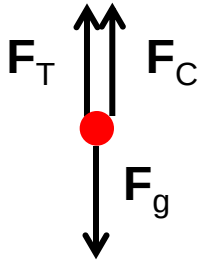
$\mathbf{F}_g$ = gravitational force

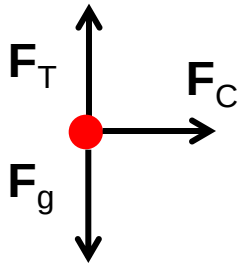
$\mathbf{F}_C$ = centripetal force

A. 

B. 

C. 

D. 

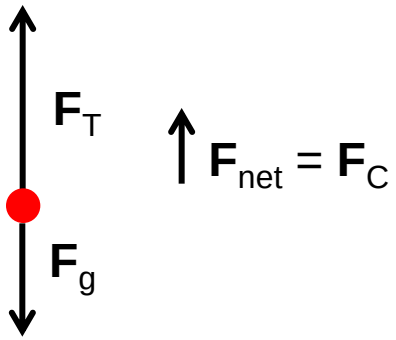
E. 

Solution

Answers: II) D, III) A

Justification:

In order for the superhero to move in a circle, there must be a net force pointing towards the center of the circle. There are only 2 forces acting on the superhero, the force of gravity pulling him down and the tension force holding him up. The tension force supplies the extra force required to move in a circle, thus the tension force must be greater than the gravitational force.

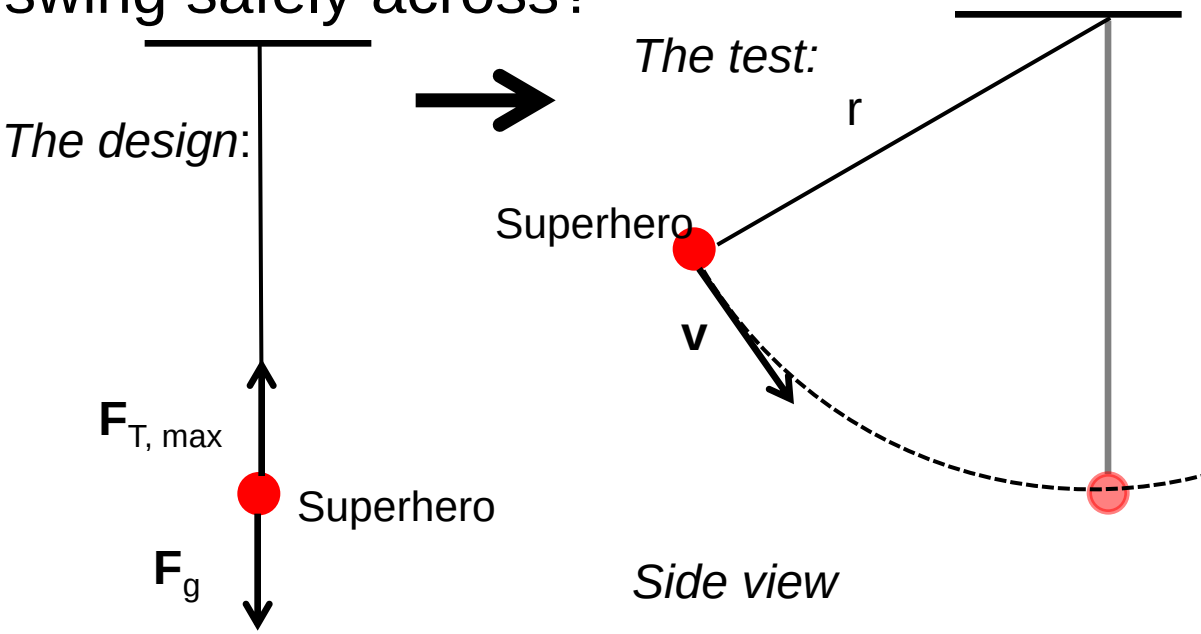


$$\mathbf{F}_T - \mathbf{F}_g = \mathbf{F}_C$$

$$F_T = \frac{mv^2}{r} + mg$$

Superhero Physics IV

A superhero is designing a new rope-like gadget that will allow him to swing from building to building. The gadget is designed so that the rope is just strong enough to hold the superhero's weight when he hangs on it. The superhero decides that the gadget is safe and tries swinging on the rope. Is the superhero able to swing safely across?



A. The superhero swings safely across

B. The rope breaks during the swing

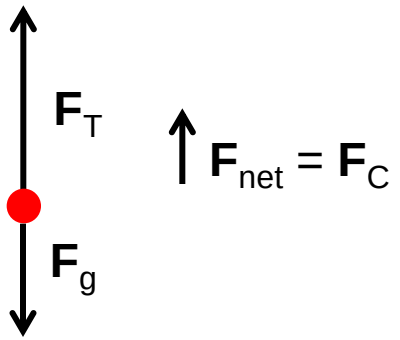
C. Cannot be determined

Solution

Answers: B

Justification: The tension force on the rope must be less than or equal to mg otherwise the rope will break.

The rope is guaranteed to break at the lowest point in the swing. As discovered in the previous question, the tension force must be greater than *mg* in order to move the superhero in a circle.



$$\mathbf{F}_T - \mathbf{F}_g = \mathbf{F}_C$$

$$F_T = \frac{mv^2}{r} + mg > mg$$