sign of approval by the concerned Board. But the system of vetting the books before giving the green signal to a publisher issuing a textbook number is ill-equipped. Allowing the reviewers a short time to do their work and yielding to the pressure from the publishers' lobby, are just a few points worth mentioning in this connection.

The experiments that are often described in school textbooks are indeed difficult to perform by a student unaided by any standard laboratory. But in most of the cases, alternate experiments do exist that can be performed with everyday objects or with limited resources, to stress the role of the same physical phenomenon. If experiments are suggested keeping these in mind, the learning process is likely to improve, where the teacher can act as a facilitator.

Incidentally, not only the science books but a significant number of mathematics text books are also laden with wrong presentation of concepts. Can the teachers' community do anything about this? Can the scientific community help in this regard? A consorted effort is indeed the need of the day.

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Relativistic resolutions of the twin paradox

In a recent article in this journal, Unnikrishnan[1] has claimed that Einstein's resolution of the twin paradox and several related resolutions are untenable. There are some points of his analysis that should be commented.

Unnikrishnan criticises Einstein for using the general theory of relativity in his resolution of the twin paradox, and for taking into account the period of acceleration of the travelling twin when he is about to return to his brother, because there exist versions of the paradox with three persons moving inertially, that have been resolved using the special theory of relativity, only.

Considering the situation with an inertial twin A and a travelling twin B, Unnikrishnan writes: 'If B's calculation invokes a differential time dilation due to a homogeneous gravitational field, then it is illogical and inconsistent to ignore it in A's calculation'.

Unnikrishnan further considers a situation with inertial clocks A, C, D at different positions and claims: 'Since all the reference clocks A, C and D are at relative rest and synchronized, the physical time dilation of B should be identical relative to each of these clocks'.

Unnikrishnan asserts that the rapid ageing of A as observed by B when B experiences a gravitational field due to his accelerated motion, 'would be violating the restrictions of absence of "spooky" instantaneous action at a distance in classical relativity'.

Unnikrishnan also considers a version of the twin paradox without any acceleration. A and B have stop watches. A emits a light signal to B that arrives just before B starts to decelerate to return. A and B stop the watches and the readings of the watches are compared when B arrives back at A. According to A, B's clock should show the least time, but according to B, A's clock should show the least time. Since both cannot be correct, Unnikrishnan concludes: 'This thought experiment shows that all standard resolutions of the twin paradox invoking acceleration or an equivalent pseudo-gravitational field as a physical effect responsible for asymmetric time dilation are flawed, and Einstein's resolution is no exception'.

Next I will point out why these claims are not correct, and then I will present a simple version of Einstein's resolution of the twin paradox.

There are different versions of the twin paradox. As a self-consistent theory, the theory of relativity must be able to resolve all of them in a consistent way, i.e. without any contradictions. I will here consider the version analysed by Einstein with only two twins, one inertial A and the other B travelling and accelerating at the point of return. The formulation of the paradox invokes the general principle of relativity and thereby the general theory of relativity, by saying that both twins may consider themselves as at rest during all of the time they are away from each other, including the period when B accelerates. The paradox then arises using only the special theory of relativity to calculate the ageing each twin predicts for the other. Then A predicts that B is younger than himself when they meet again, and B predicts that A is younger. Since the general theory of relativity has been applied in the formulation of the paradox, it is to be expected that general relativistic effects must be taken into account in the analysis of the paradox.

For simplicity I will consider a situation where B travels with constant velocity to a point P and then immediately returns with constant velocity. This involves the limit in which the acceleration that makes B return, is infinitely great for an infinitely small interval of time[2]. The corresponding situation with finite acceleration has been analysed by Eriksen and Grøn[3]. It will be shown later that even if A's calculation shows that the ageing of B while A experiences a gravitational field due to his acceleration, is finite, the corresponding ageing of A vanishes in the limit with infinitely great acceleration.

Unnikrishnan considers synchronized inertial clocks at rest relative to each other. Then he notes that in the accelerated rest frame of B there is a homogeneous gravitational field and that according to the standard relativistic analysis, the clocks age by a position-dependent rate in this field. He concludes that this is not possible as cited earlier in the communication. It seems that his conclusion is due to an assumption that the state of synchronization of the clocks is invariant against a change of reference frame. This is, however, not the case, which makes his conclusion untenable.

Unnikrishnan also considers two clocks A and B at different positions. The rate of ageing of A as measured by B depends upon the state of motion of B. Changing the state of motion immediately implies a change of the rate of ageing of A, Unnikrishnan says that this implies an action at a distance which is not allowed in the theory of relativity. However, the situation is not interpreted in this way according to the theory of relativity. According to this theory, the observed kinematic properties of space–time depend upon the motion of the observer. This is not to be thought of a sort of dynamic action. It is not something spreading out from, say the observer, with infinite velocity. According to the standard interpretation of the theory of relativity, there is no action involved at all. Space–time just has the character that its observed kinematic properties depend upon the state of motion of the observer.

The stop watch version of the twin paradox considered by Unnikrishnan is new. At first sight it points to an inconsistency of the theory of relativity, since the reciprocy of the time dilation predicted by the theory in this experiment seems to lead to a self-contradiction. But again a deeper analysis solves the problem.

According to A, the twin B travels a distance l_0 with a velocity v. Hence as measured on A's clock, the travel time of B is l_0/v. The prediction of A is thus that when he compares his clock with that of his brother, his own clock will show l_0/v and B's clock will show $l_0/v\sqrt{1-v^2/c^2}$.

B observes a Lorentz-contracted distance between the position of A and the position where he receives the signal from A, $l = l_0\sqrt{1-v^2/c^2}$. Hence according to B, the travel time of A is $l/v = l_0/v\sqrt{1-v^2/c^2}$. So B predicts that his own clock will show this time when he compares it with A's clock. This is in agreement with A's prediction. If we follow Unnikrishnan, we would now say that due to the relativistic time dilation, B would predict that A's clock shows $(l/c)\sqrt{1-v^2/c^2} = (l_0/v)(1-v^2/c^2) = l_0/v - vl_0/c^2$, which is different from A's own prediction. Hence, there seems to be a contradiction.

However, one point has not yet been taken into account: the relativity of simultaneity. According to the Lorentz transformation, two events that are simultaneous as measured by A, are happening at different times as measured by B, the difference being equal to vl_0/c^2. This just cancels the last term above and makes B predict that A's clock will show l_0/c when they meet again, in agreement with A's own prediction.

We now consider the situation that B moves a distance l_0 with constant velocity v and then immediately returns with the same velocity. The twins compare the total travelling times as shown by their clocks when they meet after B's travel. In this version of the twin paradox, B's acceleration at the turning point is infinitely great during an infinitely brief time interval. In this case A predicts that his own clock shows a separation time $2l_0/c$ and B's clock shows $(2l_0/c)\sqrt{1-v^2/c^2}$, since both A's and B's ageing are infinitely small during B's period of acceleration as measured by A.

As calculated above, B predicts that his own clock shows a travelling time that agrees with A's prediction. However, the calculation implies that if B also neglects A's ageing during the time he experiences a gravitational field, like A did, he predicts that A's clock will show $2(l_0/v - vl_0/c^2)$, in contradiction to A's own prediction.

It remains to calculate B's prediction for A's ageing during the time B experiences a gravitational field, to see if he is admitted to neglect this in the limit of an infinitely brief period with infinitely great acceleration of gravity.

Since Unnikrishnan argued that there is a problem with clocks at different positions in A's inertial rest frame AF, I will consider an A-clock at an arbitrary position at the point of time that B starts to experience a gravitational field. It is assumed that B has a constant rest acceleration g. He is at rest at the origin of a uniformly accelerated reference frame BF. In the following we can neglect the y- and z-directions. The line element in BF is

$$\mathrm{d}s^2 = -\left(1+\frac{gx}{c^2}\right)^2 c^2\mathrm{d}t^2 + \mathrm{d}x^2 + \mathrm{d}y^2 + \mathrm{d}z^2. \qquad (1)$$

A has a free vertical motion in BF. The Lagrangian of A is

$$L = -\frac{1}{2}\left(1+\frac{gx}{c^2}\right)^2 c^2\dot{t}^2 + \frac{1}{2}\dot{x}^2. \qquad (2)$$

where the dot denotes differentiation with respect to the proper time of A. Since t is cyclic, the momentum conjugate to t is constant,

$$p_t = -\left(1+\frac{gx}{c^2}\right)^2 c^2\dot{t} = -\left(1+\frac{gx_1}{c^2}\right)^2 c^2\dot{t}_1, \qquad (3)$$

where x_1 is the initial position of A. The time component of A's four-velocity at

$$\dot{t}_1 = \gamma\left(1+\frac{gx_1}{c^2}\right)^{-1}, \quad \gamma = \left(1-\frac{v^2}{c^2}\right)^{-1/2}. \qquad (4)$$

Here v is the constant velocity of B before the acceleration starts as observed by A, i.e. it is the velocity of an A-clock with initial position $x = 0$ as observed by B at the moment the gravitational field is turned on. Hence

$$p_t = -\gamma\left(1+\frac{gx_1}{c^2}\right)c^2. \qquad (5)$$

The four-velocity identity takes the form

$$\dot{x}^2 = \left(1+\frac{gx}{c^2}\right)^2 c^2\dot{t}^2 - c^2. \qquad (6)$$

A has maximal height x_2 given by $\dot{x} = 0$, or

$$\left(1+\frac{gx_2}{c^2}\right)\dot{t}_2 = 1. \qquad (7)$$

Using

$$p_t = -\left(1+\frac{gx_2}{c^2}\right)^2 c^2\dot{t}_2 = -\left(1+\frac{gx_2}{c^2}\right)c^2, \qquad (8)$$

and eq. (5), we obtain

$$x_2 = \frac{c^2}{g}\left(\gamma\left(1+\frac{gx_1}{c^2}\right)-1\right). \qquad (9)$$

From eqs (3), (6) and (8) we get

$$\left(1+\frac{gx}{c^2}\right)^2\dot{x}^2 = c^2\left(1+\frac{gx_2}{c^2}\right)^2 - c^2\left(1+\frac{gx}{c^2}\right)^2. \qquad (10)$$

Integration gives the ageing of A, while A moves freely upwards in the gravitational field experienced by B,

$$\tau = \frac{c}{g}\left(\sqrt{\left(1+\frac{gx_2}{c^2}\right)^2 - \left(1+\frac{gx_1}{c^2}\right)^2} - \sqrt{\left(1+\frac{gx_2}{c^2}\right)^2 - \left(1+\frac{gx}{c^2}\right)^2}\right). \qquad (11)$$

The ageing of A as B experiences the gravitational field is

$$2\tau_2 = \frac{2c}{g}\sqrt{\left(1+\frac{gx_2}{c^2}\right)^2 - \left(1+\frac{gx_1}{c^2}\right)^2}. \quad (12)$$

Using eq. (9), this can be written as

$$2\tau_2 = \left(1+\frac{gx_2}{c^2}\right)\frac{2v}{g}. \quad (13)$$

In the limit of infinitely great acceleration, we get

$$2\lim_{g\to\infty}\tau_2 = \frac{2vx_2}{c^2}. \quad (14)$$

Since $x_2 = l_0$, the total ageing of A as calculated by B is $2(l_0/v - vl_0/c^2) + 2vl_0/c^2 = 2l_0/v$ in agreement with A's own prediction.

Unnikrishnan has argued that Einstein's resolution of the twin paradox contains 'logical fallacies' and 'physical flaws'. In this communication I have shown that the reason for these conclusions are that Unnikrishnan has made some errors in his applications of the theory of relativity to different versions of the twin paradox. This has also led him to conclude that most earlier analyses of this paradox are untenable, although they are, in fact, correct.

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Degradation of Himalayan forests

On the basis of only one satellite scene which covers 20,000 sq. km area and does not fully cover Almora and Pithoragarth districts, Prabhakar *et al.*[1] have tried to draw conclusions on the degradation of forests in the entire Himalayas and criticized the estimates published by Forest Survey of India (FSI) in the State of Forest Report (SFR) 1999. FSI has undertaken monitoring of the forest cover of the entire country on a regular two-year interval since early 1980s.

It appears that the authors have not read the SFR 1999 of FSI carefully. The methodology followed by FSI in the forest cover assessment has been clearly mentioned in the report (pp. 2, 3).

The authors have used the satellite imagery of IRS-ID LISS III of 31 May 1998. It is well known that the month of May is the culmination of dry season in northern India and even some of the evergreen trees like pine (*Pinus roxburghii*), which is a major species in the study area, shed major portion of their leaves (as referred by Troup 1921). The ground is dry. Even if there are a few showers of rains in May (we checked the rainfall data from India Meteorological Department) in the hills, interpretation of the satellite data is bound to give a degraded look of the forest. For example, if a scientist assesses the forest cover of an area having dense moist/dry deciduous forest using satellite data of dry season (April/May), he may conclude that there is no forest in the area or it is highly degraded. Our experience shows that not only the reduced foliage/chlorophyll on the tree, even moisture stress affects the signature in the sensor. For monitoring the forest cover of the country, FSI procures cloud-free data from NRSA for the period from October to February, so that the correct reflectance of the tree having full crown and chlorophyll content is registered. In this case, FSI has used data for the said area for the period November 1996.

The authors have made a comparison of their findings with the FSI using (%) values and not absolute area figures. About 25% area of Pithoragarh district has been left out by the authors, which is under snow and in the nonforest category; whereas FSI has used the entire area of the district in the assessment. As area of the district goes in the denominator for working out forest cover percentage, comparing such percentages becomes incorrect.

The authors have not defined the 'forest', which is the key parameter of the study. The procedure to classify the degraded forest which is below 40% of canopy density and inclusive of scrub, has also not been described. On the other hand, FSI follows the standard international classification for canopy density. Scrubs having canopy density less than 10% are categorized as 'nonforest' by FSI. If the scrub is included in the degraded forest area, the percentage of the degraded forest would obviously be inflated. The most glaring inconsistency is in table 3. The total forest cover, including scrub, is 72% in Almora, whereas FSI has estimated it as only 48%. The additional 24% area of forests estimated by the authors seems to be due to the definition adopted by them. It appears that even grasses have been included in the forests, which have been subsequently categorized as degraded forests. Obviously, when this huge area of nonforest is included in the total forest area, the percentage of degraded forests in the total forest will increase accordingly. Comparisons of degradation as shown in table 3 are therefore unscientific.

It is to be appreciated that there is a difference between a study undertaken for research purpose and the one for state and national level planning. Mention of the confident intervals is more relevant when a study is for research purpose. In the estimates which are derived for a state and national level planning, confident intervals are not quoted. FSI has described the full method of estimation of error in SFR 2001 based on statistically sound principle.

Digital image processing was introduced in FSI in 1990s and became operational only in the year 2000. FSI results used by authors for comparison are based on visual interpretation of 1 : 250,000 scale images having minimum cartographic limit of 25 ha. The two datasets are therefore not comparable. If the authors were interested to make a scientific comparison